

Argonne National Laboratory Institutional Plan

FY 2003 – FY 2007

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Pioneering Science and Technology

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Argonne National Laboratory

INSTITUTIONAL PLAN

FY 2003 – FY 2007

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This October 2002 *Institutional Plan* was originally prepared in the early spring of 2002. It generally describes the activities and plans of Argonne National Laboratory as of that time. Thus, for example, financial data for FY 2002 are mid-year projections. In addition, a few selected revisions to the *Draft Institutional Plan* of May 2002 are included to reflect comments received and major shifts in plans.

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Organization Chart

I. Laboratory Director's Statement

As a member of the national laboratory system, Argonne has carried out world-class research and development for more than 55 years, addressing many of DOE's missions and most in the Office of Science. Our current programs focus on basic science, environmental quality and assessments, energy, and national security. Secretary of Energy Abraham has stated that national security is DOE's overarching mission. Argonne is well positioned to support this mission; much of our basic and applied research, though it is carried out in support of scientific and engineering missions, has application to homeland security.

To enhance our performance in carrying out DOE's missions, Argonne and the University of Chicago — which has operated the Laboratory for its entire history — are making good progress on a management initiative to strengthen their ties and to increase research collaborations between the two institutions.

National User Facilities

Over the decades, the national laboratory system has proven highly effective at planning, designing, building, and operating user facilities. These one-of-a-kind research engines help maintain and advance U.S. scientific leadership by providing crucial support for national communities of researchers in many fields. Argonne operates three of DOE's major national user facilities:

- The *Advanced Photon Source* (APS), Argonne's premier user facility, provides researchers with the nation's brightest x-ray beams. Built and operated for DOE's Office of Basic Energy Sciences, this facility serves the national research community in a broad spectrum of scientific and technological areas, including materials science, structural biology, environmental studies, and applied engineering. Collaborative access teams — composed of investigators from private industry, universities, government, and other institutions — have committed a quarter

billion dollars in capital investments for construction of APS beamlines.

- The *Intense Pulsed Neutron Source* (IPNS) is widely known as one of DOE's exemplary user facilities, particularly because the machine and its operators embody the professional values of its national user community and serve the community's scientific interests. In the 20 years since its inaugural run, the IPNS has become a national model for user facility operations. The IPNS and its staff have committed their expertise to supporting the Spallation Neutron Source (SNS) project, soon to become the nation's premier neutron source, by designing and building instruments for the SNS and by training many of the future SNS users.
- The *Argonne Tandem-Linac Accelerator System* (ATLAS) is the world's first superconducting linear accelerator for heavy ions and the premier accelerator for low-energy nuclear physics research. In addition to supporting an active and productive community of physicists from all over the world, ATLAS plays a key role in Argonne's conceptual design for the Rare Isotope Accelerator.

Major Research Initiatives

To complement existing programs, Argonne works closely with DOE and the scientific community — often in a leadership role — to develop new initiatives and scientific facilities to serve national needs. The following five initiatives represent timely opportunities to significantly enhance U.S. research capabilities in basic research and development and hence to advance scientific understanding and engineering achievement across a wide range of disciplines:

- *Nanosciences and Nanotechnology.* Research on nanoscale materials will lead to devices such as computers that are smaller and more efficient and to materials with new and exciting properties. Argonne is well

positioned to contribute to these national goals and is actively developing regional collaborations to help the nation seize this important opportunity. One of the Laboratory's forefront research areas is nanomagnetism, in which electron spin controls current flow in a new generation of magnetic electronic devices. DOE has identified Argonne as one of its sites for a Center for Nanoscale Materials. The state of Illinois has appropriated \$17 million of its FY 2003 budget for design and construction of a building to house the center, which will adjoin the APS and serve as a research and user outreach facility. Another \$17 million will be sought in the FY 2004 budget to complete construction.

- *Rare Isotope Accelerator.* The Rare Isotope Accelerator (RIA) has been designated the highest priority among new construction projects for the physics community by both DOE's *Long-Range Plan for Nuclear Physics* and the National Research Council's Committee on Nuclear Physics. By accelerating highly unstable nuclei at the very limits of existence, RIA will open new scientific frontiers. Physicists will study the processes by which stars generate energy and create heavy elements, discover new and unexpected phenomena, and develop new approaches to studying nuclear decay, reactions, and structure. In collaboration with Michigan State University and other institutions, Argonne has developed a facility concept that achieves RIA's physics goals at reasonable cost by incorporating Argonne's existing state-of-the-art heavy-ion accelerator, ATLAS. The state of Illinois has appropriated \$16.6 million of the \$19.6 million planned for a user office building adjoining RIA.

- *Functional Genomics.* Recent developments in genome-wide DNA sequencing, high-throughput analytical tools, and computing technologies have made feasible the genome-wide analysis of biomolecular function. Such research could lead to new strategies for altering cellular activities to improve human health, environmental management, and economic productivity. It could also help DOE pursue its homeland security mission by deepening understanding

of organisms used as biological warfare agents. To address this opportunity, Argonne is developing a major Laboratory initiative to undertake large-scale functional analyses of macromolecules and macromolecular complexes. The Laboratory is also strengthening its research staff in order to contribute to the latest developments in this fast-moving field. A partnership between Argonne's Biosciences Division and the Mathematics and Computer Science Division will coordinate the efforts of experimentalists and simulation experts to develop exciting new capabilities in bioinformatics and computational cell biology.

- *Advanced Computing.* Argonne has established an initiative in Petaflops Computing and Computational Science to spur development of petaflops computing and associated scientific applications. The computational science component will provide expertise and midrange computer resources so Laboratory research groups can begin to apply more advanced computational methods to their work and prepare for larger-scale computing opportunities. The R&D component will focus on designing and deploying a petascale system by 2006 and will support development of next-generation modeling capabilities in many scientific fields, including life sciences, nanoscience, energy systems, and the environment. The initiative envisions construction of a large-scale research facility to house a petaflops computing system and supporting programs in collaborative computational science research.

- *Advanced Nuclear Fuel Cycle.* We recognize that the U.S. industry initiative to simultaneously deploy five to ten economical new nuclear plants by 2010 must succeed, and we urge the government to provide adequate funding to leverage this critical initiative. Looking beyond the current industry initiative, widespread deployment of hundreds of large nuclear power plants cannot be achieved without meeting requirements for safety, economics, nuclear nonproliferation, sustainability, and reduced waste toxicity that expands repository lifetime and capacity. To meet these future needs, the nuclear industry must develop a closed fuel cycle. Argonne

proposes to collaborate with industry and other laboratories to develop and demonstrate such a fuel cycle, based on proliferation-resistant, fast-spectrum nuclear reactors.

The state of Illinois has provided extremely valuable support for Argonne's major research initiatives. This outstanding cooperation has fostered a very favorable environment for accomplishing the Laboratory's mission.

Management Initiatives

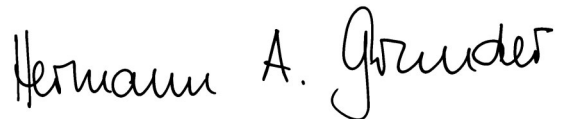
The most important measure of an organization is the quality and dedication of its people. We are pursuing a number of management initiatives to help maintain the high quality of Argonne's staff:

- *Review of Performance Appraisal System.* A team of senior Argonne staff has examined the Laboratory's system for evaluating employee performance. Although performance appraisal was the primary focus, career-development paths and the compensation system were also examined. The team obtained benchmark information from several DOE laboratories, collected "best practices" from other research organizations, and gathered employee input. The team's recommendations are now being implemented.
- *Making Optimal Use of the National Talent Pool.* To maintain high-quality staff, it is essential to attract the best qualified new employees from all ethnic and cultural backgrounds. Senior Argonne management recognizes the need to make better use of the

nation's intellectual resources and is actively working to increase the diversity of the Laboratory's staff.

- *Integrated Management.* A key aspect of laboratory management is ensuring that line managers are responsible for achieving excellent performance in the full range of activities under their purview, including safety and security dimensions. At the same time, every employee must feel empowered to step up and stop work if he or she believes that safety or security is not adequately protected. This integrated management approach requires ongoing education and training of all staff.

- *Communications Synergy.* When communication flows unimpeded in all directions throughout an organization, the resulting interactions produce fertile synergies and great new ideas. We are making open communications a key part of the Argonne culture across all levels of management and staff. Open communication is necessary to ensure that line management learns of all available good ideas and can help implement them.



Hermann A. Grunder
Laboratory Director

II. Mission, Roles, and Strategic Objectives

A. Vision and Mission

Argonne National Laboratory is a major multiprogram laboratory managed and operated for the U.S. Department of Energy (DOE) by the University of Chicago under a performance-based contract.

Argonne's vision is to be a world-leading laboratory for advancing and applying science, engineering, and forefront user facilities in service to DOE and the nation. To achieve this vision, Argonne solves problems of national interest that are at the frontiers of science and technology and delivers outstanding results to DOE and other sponsors in a manner that is cost-effective and timely, and that strives continually for improvement — in management, administration, operations, safety, environmental stewardship, security, and relationships with neighbors.

Argonne's mission is to serve DOE and national security by advancing the frontiers of knowledge, by creating and operating forefront scientific user facilities, and by providing innovative and effective approaches and solutions to energy, environmental, and security challenges to national and global well-being, in the near and long term, as a contributing member of the DOE laboratory system.

Argonne contributes significantly to DOE's missions in science, energy resources, environmental stewardship, and national security, with lead roles in science, operation of scientific facilities, and energy. In accomplishing its mission, Argonne partners with DOE, other federal laboratories, the academic community, and the private sector.

B. Scientific and Technical Core Competencies

Argonne cultivates distinctive, world-class scientific and technical capabilities and integrates them into a dynamic portfolio of core

competencies that serve and anticipate current and emerging national R&D needs in the Laboratory's mission areas. The Laboratory's current competency portfolio includes the following:

- A complete set of engineering and scientific expertise supporting the design, development, and evaluation of advanced nuclear energy systems and proliferation-resistant nuclear fuel cycle technologies, including pyroprocessing.
- Design, construction, and operation of accelerator-based user facilities, along with diverse state-of-the-art capabilities related to acceleration, particle detection, synchrotron radiation techniques, spallation-neutron scattering techniques, and the control and manipulation of particle beams and photon beams.
- Fundamental science and engineering expertise in, and at the interfaces among,
 - Materials sciences, chemical sciences, and atomic physics;
 - High energy and nuclear physics;
 - Multidisciplinary nanoscience and nanotechnology;
 - Structural biology, functional genomics, and bioinformatics;
 - Environmental science and technology;
 - Applied mathematics and computer science, including collaborative and virtual environments; and
 - Computational science, including modeling, simulation, systems analysis, and complex adaptive systems.

Argonne's goal in managing its portfolio of core competencies is to be best in the world in selected areas, to be among the leaders in other areas, and to have sufficient breadth and balance both to support users of the facilities it stewards and to tackle complex multidisciplinary challenges in its mission areas — typically in collaboration or partnership with others.

C. Roles in Accomplishment of DOE Missions

Argonne has a contractual responsibility to serve DOE's mission areas, especially its overarching national security mission. In **Science** and in **Energy**, the Laboratory has a principal role. Its role in **Environmental Quality** is as a major contributor. September 11 demonstrated how fundamentally the Laboratory's knowledge, technologies, and facilities — even those originally developed for other purposes — are a major resource for **National Security**.

1. National Security

The tragic events of September 11 both amplified and focused Argonne's involvement in DOE's **National Security** mission. Intensified contributions draw on substantial Laboratory expertise in nuclear, chemical, and biological disciplines and in systems analysis and modeling. Argonne also devises highly sensitive instruments and verification technologies to detect radiation, chemical threats, and biological clues to possible weapons proliferation or attacks. Finally, the Laboratory's modeling and decision science skills contribute to critical infrastructure assurance at local, regional, national, and global scales. Over the years, Argonne scientific and engineering work originally pursued for other purposes has yielded many results that today help counter terrorism.

2. Science

For DOE's **Science** mission, Argonne operates major scientific user facilities and has significant experimental and theoretical research programs in nuclear and high energy physics, in applied mathematics, and in materials, chemical, computer, computational, biological, environmental, and fusion science. In several key fields and subfields important to DOE, the Laboratory's research is among the most cited, and its scientists are international leaders. Argonne takes pride in effective collaborations with other DOE laboratories, strong interactions with the academic community, productive R&D partnerships with

private industry, and high-quality research experiences provided for a few hundred undergraduate and graduate students each year.

Three of DOE's most successful major **national scientific user facilities** are at Argonne: the Advanced Photon Source (APS), the Intense Pulsed Neutron Source (IPNS), and the Argonne Tandem-Linac Accelerator System (ATLAS). The APS, the nation's premier hard x-ray synchrotron radiation facility, now serves more than 4,000 users from universities, corporations, and national laboratories throughout the country, and it routinely reports newsworthy new science. In 2002 the IPNS continued to provide extraordinarily reliable neutron beams and user support for approximately 400 experiments, while continuing its tradition of leadership in the development of spallation targets, neutron moderators, and neutron-scattering instruments. IPNS celebrated its 20th birthday and was recently designated a Nuclear Historic Landmark by the American Nuclear Society. In addition to operating the APS and IPNS, Argonne educates the next generation of users by hosting the National School for Neutron and X-ray Scattering. Unique low-energy heavy-ion beams from ATLAS enable over 100 scientists per year to conduct forefront research in nuclear, atomic, and applied physics. The Rare Isotope Accelerator (RIA) — recently identified by the nuclear physics community as its highest priority among major new construction projects — derives considerable scientific motivation and technology base from ATLAS.

For several years Argonne has made significant contributions to major subprojects associated with user facilities or detectors located elsewhere. The most visible current example is the Laboratory's participation in the Spallation Neutron Source (SNS). Argonne has leading responsibility for SNS spectrometer systems and provides substantial technical support for SNS target systems. Other examples include contributions to the ATLAS detector for the Large Hadron Collider, participation in the Linac Coherent Light Source, and detector fabrication for the MINOS neutrino experiment.

Science at Argonne benefits from access to major facilities and from the Laboratory's integrated approach to complex problems. The

grand challenges in modern science, like nanoscale materials or fundamental understanding of biological processes at the molecular scale, are beyond the reach of isolated experiments. Success requires not only forefront capability but also a suite of experimental and theoretical approaches. Argonne's strength comes from diverse scientific teams that examine a problem from many complementary perspectives. This synergy of many approaches working together creates remarkable scientific power and often leads to the creation of pathbreaking new facilities. The APS, IPNS, and ATLAS accelerator all had their origins in Argonne science.

Four of the five major Laboratory initiatives featured in Chapter III of this *Institutional Plan* build on Argonne strengths to enable future accomplishment of DOE's **Science** mission, both through conducting forefront science and through service to users. Those four initiatives are the Center for Nanoscale Materials, the Rare Isotope Accelerator, Functional Genomics, and Petaflops Computing and Computational Science.

3. Energy

For its **Energy** mission, DOE has designated Argonne and the Idaho National Engineering and Environmental Laboratory as co-lead laboratories for nuclear reactor technology. In addition, the Laboratory has substantial programs and facilities serving DOE's mission to develop innovative, energy-efficient, cost-effective, and environmentally friendly technologies for electric power, transportation, and industry. Since the 1970s Argonne has cultivated capabilities and programs — and has produced results — that are well aligned with recommendations of the Administration's energy policy, as described in the May 2001 *Report of the National Energy Policy Development (NEPD) Group*. Argonne operates numerous unique energy R&D facilities that are used by researchers from universities and industry.

Argonne has noteworthy expertise and facilities in nuclear reactors and nuclear fuel cycle technologies. Over the years, the Laboratory has developed safe and reliable fast-reactor technologies and has laid the technical groundwork for

a proliferation-resistant closed nuclear fuel cycle, based on pyroprocessing, that can consume weapons-grade plutonium and spent fuel from the nation's current fleet of power reactors. The Laboratory is ready to contribute solutions that will allow nuclear energy to be a significant, safe, environmentally acceptable, proliferation-resistant, growing, sustainable, and economical component of the nation's energy supply portfolio, in both the near and long term. The major Laboratory initiative on Advanced Nuclear Fuel Cycle envisions a closed, environmentally sound nuclear fuel cycle that generates electricity while reducing inventories of plutonium and the long-term toxicity of the waste generated.

Argonne's broader energy R&D portfolio is built on expertise in superconductivity, fuel cells, fossil fuels and carbon management, renewable energy technologies, energy testing and analysis, and other key technologies. Transportation technology R&D relies on many of these competencies and on unique Laboratory facilities to support DOE's quest to increase the efficiency and productivity of vehicular energy use while limiting environmental impacts.

4. Environmental Quality

In support of DOE's **Environmental Quality** mission, Argonne develops innovative characterization and remediation tools and technologies, creates advanced technologies that intrinsically produce little or no pollution and minimize waste generation, cleans up land and facilities on the Argonne sites, and conducts thorough and objective environmental analyses. The focus of this work is shifting from effluent control technologies and associated regulation toward resource and waste management, site remediation, long-term stewardship, and global environmental issues. The Laboratory's strength is its combination of capabilities in bioprocessing, ecology, modeling and measurement of environmental pathways, atmospheric physics and chemistry, environmental assessment, and decision models. Argonne is responsible for operation of all three Cloud and Radiation Testbed (CART) facilities of DOE's Atmospheric Radiation Measurement (ARM) Program. The Laboratory is using the APS to pioneer synchrotron-based environmental tools

to deepen microscale understanding of environmental processes, and it belongs to the EnviroCAT partnership, which has been approved to develop state-of-the-art APS beamlines specially designed to tackle a broad range of environmental science problems. Late in FY 2001 the U.S. Department of the Interior tapped Argonne to develop the environmental impact statement for the Alaska Pipeline.

5. Enabling the Mission through Excellence in Operations

Built into all Argonne programs and support activities is a commitment to **operational excellence**, to exemplary **relations with the public** (especially neighbors near the Illinois and Idaho sites), and to development of the diverse **science and engineering workforce** needed to accomplish DOE missions and assure U.S. prosperity, security, and leadership into the future. In the operations area, the Laboratory's contractual goal is to conduct all work and operate all facilities cost-effectively and with distinction, in a manner that integrates with and supports Argonne's missions in science, technology, energy, and environment, while fully protecting its workers, its users, the public, the environment, and national interests.

For more than 55 years, the University of Chicago has, as a public service, managed and operated Argonne under contract to the federal government. As a result, the Laboratory's research environment and performance have maintained a high standard of intellectual excellence and integrity, and the site — despite its age — is among the best maintained in the DOE complex. Currently, the University and the Laboratory are strengthening ties at all levels, from student research to joint appointments, collaborations between individual investigators, and strategic alliances.

D. Strategic Context and Planning Assumptions

Argonne is one of DOE's nine major multiprogram national laboratories, and it is one

of ten facilities affiliated with DOE's Office of Science. Like most DOE R&D sites, Argonne is managed and operated by a contractor. The Laboratory is unique among Office of Science laboratories in encompassing two widely separated campuses: the main site at Argonne-East in the Chicago suburbs and Argonne-West (with major nuclear facilities) in eastern Idaho. The Laboratory serves all four of DOE's missions and is internationally recognized for its science, scientific user facilities, and energy R&D. Argonne's track record of performance, its human resources, and its R&D facilities are the assets upon which the Laboratory's strategic plan for the future is built.

Argonne's planning is based on five assumptions:

- DOE's national laboratories must act increasingly as a synergistic system, with the laboratories managing their collective competencies, increasing their overall cost-effectiveness, and partnering on major initiatives among themselves and with the private and academic sectors.
- Sponsors, regulators, and the public will continue to require that Argonne demonstrate responsible corporate citizenship. This imperative includes being a good and trustworthy neighbor, conducting operations cost-effectively and responsibly, and meeting or exceeding regulatory requirements.
- Argonne will need to compete on its merits for federal funding, for the "best and brightest" employees, and for the modern infrastructure needed for future success. Important factors in this competition will be scientific and technological excellence, cost-effectiveness, mission contributions, record of performance, and a working environment that enables high performance from a diverse and talented workforce.
- Robust links with universities, industry, federal laboratories, and the general scientific and technical community (within the United States and abroad) are essential for Argonne to maintain its leadership stature and fully exploit advances made throughout the world.

- Computing, computational science, and communications and information technology will advance rapidly, will become seamlessly intertwined with experimental science, and will thereby revolutionize many fields of research and applications that are central to the missions of DOE and Argonne.

E. Strategic Objectives

Objective 1. Argonne will continue to perform outstanding science and technology consistent with its missions and will provide results and value to the nation. This objective includes operating its world-class scientific user facilities and providing other science- and technology-based tools in a way that maximizes service to users and productivity of research, as well as other public benefits. Outstanding science and technology are Argonne's *raison d'être*. The Laboratory's history of accomplishment is the basis on which it becomes the performer of choice in its mission areas. In support of this objective, Argonne expands the frontiers of knowledge, develops and tests new technologies, and creates new areas of inquiry that keep it at the forefront. Thousands of scientists and students from universities, industry, and other laboratories around the country and the world use the unique facilities operated by Argonne to conduct their research. Reliable facility operation, meeting or exceeding performance specifications, and high-quality user support are critical. In addition to APS, IPNS, and ATLAS, Argonne operates or provides other important special research tools, such as major nuclear research facilities, environmental research sites, mathematical libraries, software packages, and decision tools.

Argonne has an obligation to the taxpayer to provide the highest possible mission value with the resources it receives. Under constrained or declining budgets, this goal can only be achieved by growing the best, most important programs and phasing out the least important. Only by making such choices can the Laboratory ensure that the research it undertakes achieves the required quality and stature. In the near term, Argonne will emphasize expanding and strengthening the computational components of its R&D, operating user facilities effectively, exploring promising

areas at the interfaces among traditional disciplines, solving problems of national importance, and catalyzing the expeditious transfer of its technologies into beneficial use. Chapter IV provides updated plans for each of Argonne's science and technology areas.

Objective 2. Argonne will develop important new R&D initiatives and scientific facilities that serve emerging national needs consistent with its mission and will implement them cost-effectively and expeditiously to the benefit of DOE and the nation. New initiatives are an engine for change. They attract bright research staff and facility users, and they help direct the Laboratory's programmatic focus onto current and future needs. Each year Argonne features a few Laboratory-scale initiatives that promise extraordinary, broad benefits and that build naturally on Laboratory mission areas and strengths. This year's portfolio includes the Center for Nanoscale Materials, the Rare Isotope Accelerator, Functional Genomics, Advanced Nuclear Fuel Cycle, and Petaflops Computing and Computational Science. Chapter III summarizes each of these five Laboratory-scale initiatives.

Objective 3. Argonne and the University of Chicago will strengthen and fully exploit partnerships and alliances to maximize the Laboratory's value and impact — nationally, regionally, and locally. A strong intellectual alliance between the University of Chicago — one of the nation's premier research universities — and Argonne — one of DOE's major multiprogram science laboratories — promises benefits to DOE and to the prestige and impact of each institution. With this motivation, Argonne and the University are increasingly taking advantage of each other's complementary expertise in areas such as nanoscience, computing and computational science, bioscience, environmental science and impacts, and homeland security. To accomplish this objective, the two institutions plan to increase joint recruiting, joint proposals, joint appointments, joint projects, and sharing of facilities and other resources.

Objective 4. The University of Chicago and Argonne will continuously improve the cost-effectiveness, management, and operations of the Laboratory. The University of Chicago is working with DOE to continuously improve and streamline

Argonne's administration and operation. Major challenges include recruiting and developing a diverse workforce for the Laboratory's future, modernizing the physical infrastructure, and fully exploiting partnerships. The changes undertaken in this quest will build on best practices gleaned from the private, academic, and public sectors. The result will be an integrated, creative, and high-performing laboratory whose performance

significantly exceeds the sum of its parts, because it engages — cost-effectively, safely, securely, and productively — as a contributing member of the DOE laboratory system and as a partner and leader in addressing national needs in science and technology. Chapter V and Supplement 3 in this *Institutional Plan* provide updated descriptions of status and plans in operations areas.

III. Major Laboratory Initiatives

The Laboratory's second strategic objective is stated in Chapter II: "Argonne will develop important new R&D initiatives and scientific facilities that serve emerging national needs consistent with its mission and will implement them cost-effectively and expeditiously to the benefit of DOE and the nation." This chapter provides planning "snapshots" of Argonne's major Laboratory initiatives, for consideration by DOE.¹ The Laboratory's initiatives represent important opportunities to enhance U.S. research capabilities, to serve the broader scientific community, and to advance scientific understanding and engineering achievement across a wide range of disciplines.

Argonne carefully considers the implications of the National Environmental Policy Act (NEPA) for its scientific and technical initiatives, as early as it is reasonable to do so. For initiatives where NEPA implications are expected to be significant, the implications are discussed explicitly in this *Institutional Plan*.

The five major Argonne initiatives relate most closely to two DOE mission areas, Science and Energy:

- Science
 - Nanosciences and Nanotechnology — Center for Nanoscale Materials
 - Rare Isotope Accelerator
 - Functional Genomics

- Petaflops Computing and Computational Science

- Energy

- Advanced Nuclear Fuel Cycle

A. Science

1. Nanosciences and Nanotechnology — Center for Nanoscale Materials

The National Nanotechnology Initiative is an interagency effort driven by the realization that present-day materials and processes are reaching their limits of performance. Fundamentally new approaches are needed to transcend these limits. The emerging field of nanoscience offers the requisite scientific and technological opportunities. Accordingly, DOE has taken the bold step of establishing five new Nanoscale Science Research Centers at its national laboratories. Argonne's Center for Nanoscale Materials (CNM) was approved in FY 2002 as one of the five.

Argonne's vision is to go beyond present-day semiconductor materials and processing methods to create new functional materials on the nanoscale. Highlights of the Laboratory's plan include focusing on chemical methods to self-assemble nanostructures, to pattern nontraditional electronic materials, and to create new probes for exploring nanoscale phenomena. Moreover, the Laboratory aspires to help pioneer the new fields of molecular and magnetic electronics.

The CNM will serve simultaneously as a forefront research center and as a user facility for the regional and national research communities. Previously, DOE's stewardship of the nation's major materials science user facilities (such as the Advanced Photon Source [APS] and Intense Pulsed Neutron Source [IPNS] at Argonne) focused on the advanced *characterization* of materials. The CNM will be part of a new generation of DOE user facilities because its primary goal is to *fabricate* advanced nanoscale materials.

¹ Inclusion of initiatives in this chapter does not necessarily imply approval, or an intention to implement, by DOE. All funds received for initiatives during FY 2002 are included in the resource tables in Chapter VI of this *Institutional Plan*. However, resources required for proposed growth of initiatives in years beyond FY 2002 are generally not included in those projections. Projected resource requirements for all initiatives include costs associated with protection of the environment and the health and safety of workers and the public.

The CNM will complement Argonne's existing user facilities and enhance their value by creating cutting-edge nanomaterials that require advanced characterization. To maximize this synergy, the new building for the CNM will adjoin the APS, and the CNM will construct a state-of-the-art, hard x-ray nanoprobe beamline at the APS. The new beamline will focus hard (i.e., 10 keV) x-rays down to an unprecedented spot size of 30 nanometers. This capability will enable a variety of imaging, spectroscopic, and diffraction experiments that cannot be performed similarly anywhere else in the world.

The signature new technology of the last half of the 20th century was solid-state electronics. The 21st century is expected to be marked by the creation of connections across the biointerface, and a major focus of the CNM will be creating novel interconnections between soft matter (complex organic and biological molecules) and hard matter (solid-state nanoparticles and patterned systems). Major areas of interest will include the flow of chemical energy and the propagation of light. Initial Argonne work in these areas has been supported by Laboratory Directed R&D funding and, more recently, by funding of Argonne proposals in response to the DOE Nanoscale Science, Engineering, and Technology call.

Magnetic nanomaterials hold much promise to advance the future of electronics, despite the fact that magnetic materials are among the oldest of technological materials (starting with the use of lodestones for ships' compasses). Today, magnetic nanomaterials promise to revolutionize computer design. Computers already use magnetic nanosystems in hard disk drives to store and read data, and the data density of such magnetic recording devices is doubling every nine months. In the future, nanomagnetic devices may also be used to control the flow of current in the computer's logic elements, which could enable programmable processors that transcend the fixed architectures of today's circuitry. Such processors could be reconfigured dynamically to optimize performance for the particular task at hand. Currently under industrial development are magnetic random access memories that may ultimately provide nonvolatile electronics, including laptop computers capable of "instant bootup."

Realizing these technological opportunities requires fundamental studies of magnetic materials on the nanoscale. Argonne is positioned to take a leadership role within the DOE system in this challenging area. Work on nanomagnetism at the CNM will create new nanostructures by using chemical methods of self-assembly, as well as lithographic patterning of novel thin-film hybrid systems. Utilizing the spin (magnetism) of the electron, in addition to its charge, is opening the new field of magnetic electronics (spintronics). The mission of the CNM will include spintronics, along with molecular electronics and nanophotonics, in the effort to develop new functionalities at the nanoscale.

The CNM will energize new collaborations and partnerships that broaden the user community throughout the Midwest and the nation. To foster this user community and stimulate feedback from users, general and specialized workshops have been held, and more are being planned. Research themes already covered include the x-ray nanoprobe, neutrons and nanoscience, and industrial microfabrication. The University of Chicago-Argonne Consortium for Nanoscience Research was launched in 2001. Principal investigators from both institutions are cooperating to pursue initial research themes that embrace major focal areas for the CNM. The investigators also have begun ambitious planning for intellectual cross-pollination and educational outreach.

An emerging prime interest for the CNM is the role of theory in creating computational algorithms that simulate nanoscale phenomena. Now under way are efforts to define the scope of a research theme within the CNM dubbed the "Virtual Fab Lab." The objective is to use large-scale computational strategies to transform nanofabrication from an art into a science. The concept of the Virtual Fab Lab in the context of the CNM will be the topic of a future workshop, and it creates linkages with the Petaflops Computing and Computational Science initiative described in Section III.A.4.

The excitement of planning science for the CNM is being enhanced by planning for its infrastructure. The state of Illinois has committed funds for construction of the CNM building. M.W. Zander was selected as the architectural and

engineering firm to design the building, and its work has begun. Selection of a firm to oversee construction is under way.

The CNM initiative requires investments in the following three complementary areas:

1. *Personnel.* Argonne's staff includes some of the researchers required for this initiative, and several of the Laboratory's core programs will naturally move in directions complementary to the CNM. Many new staff members with special expertise will be recruited in areas such as self-assembly, lithography, advanced spectroscopies, and imaging. In addition, creation of the Virtual Fab Lab will require critical new staff in the areas of theory and computational nanosciences.

2. *New Tools for Nanofabrication.* Electron lithography and focused-ion-beam lithography are essential tools for fabrication of nanostructures. Also required is equipment for etching, deposition, and other processes. Several of these tools do not exist elsewhere in the Midwest and will strongly attract outside users. Clean rooms and related infrastructure will be developed; nanostructures are much smaller than a speck of dust, and scrupulously clean conditions are needed for their fabrication.

3. *New Tools for Nanocharacterization.* Tools for visualizing nanostructures, especially microscopes (x-ray, electron, scanning probe, and near-field optical), will be further developed at Argonne. The x-ray nanoprobe will be developed to use the brilliance of the APS to probe at the nanoscale. The Laboratory's Electron Microscopy Center (Section IV.A.1.b) will be enhanced by synergies with the CNM, and the IPNS will attract new users because of new materials created by the CNM.

Resources required for this initiative are summarized in Table III.1. Argonne is working with the state of Illinois to construct the building for the CNM by January 2006. Further funding for instrumentation and research operations is being sought from DOE-Basic Energy Sciences (DOE-BES; KC-02, KC-03, and KC-04) and also from the state of Illinois and other sources.

Table III.1 Nanosciences and Nanotechnology — Center for Nanoscale Materials (\$ in millions BA, personnel in FTE)^a

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating ^b	0.4	1.0	7.8	12.3	17.3	17.3	17.3
Capital Equipment	-	6.8	18.1	18.1	-	-	-
Construction ^c	2.0	17.0	17.0	-	-	-	-
Total	2.4	24.8	42.9	30.4	17.3	17.3	17.3
Direct Personnel	-	4.0	30.0	46.0	59.0	59.0	59.0

^aArgonne's nanoprobe beamline was approved for funding by DOE in FY02. Other parts of the CNM will be funded starting in FY03.

^bNot included here is funding for in-house nanoscience research. Argonne will compete for this funding separately. This additional funding is expected to be similar in magnitude to the initiative's operating funding.

^cThe state of Illinois is funding construction of a building for the CNM.

2. Rare Isotope Accelerator

Opening of new frontiers for research in nuclear physics is expected through the acceleration of beams of unstable nuclei (rare isotopes). Critical information previously impossible to obtain includes (1) cross sections for astrophysical processes such as nucleosynthesis during and shortly after the Big Bang, energy-generating processes in stars, and heavy-element production via the r-process during supernova explosions; (2) qualitatively new and unexpected nuclear structure effects in nuclei far from stability, at their very limits of existence; and (3) completely new approaches to studies of nuclear decay, reactions, and structure. These opportunities have triggered considerable excitement in the scientific community worldwide.

Exploration at these frontiers will require extension of today's technical capabilities and facilities. This need and its scientific basis have been discussed thoroughly in a number of forums in the past decade, both in the United States and abroad, including the 1999 National Research Council's Committee on Nuclear Physics. Most recently, the compelling scientific opportunities offered by research with rare isotopes led the DOE-National Science Foundation Nuclear Science Advisory Committee (NSAC) in its 2002 *Long Range Plan for Nuclear Science* to

recommend the Rare Isotope Accelerator (RIA) as the field's highest priority for major new construction and to conclude that RIA is required to ensure U.S. leadership in the areas of nuclear structure and nuclear astrophysics.

In collaboration with Michigan State University and other U.S. research institutions, Argonne developed a facility concept that will achieve the physics goals set forth by NSAC. The facility is currently envisioned to have a construction cost of approximately \$650 million (in FY 2002 dollars) and a total project cost of under \$1 billion (BA). Technology development related to RIA is currently under way at eight institutions, including both universities and national laboratories. The expectation is that the RIA project itself will also involve a national team. The preliminary budget profile in Table III.2 is for the entire project and team. Argonne is working with the research community to organize the RIA team and prepare a preconceptual design report.

In parallel with consideration of the fundamental science to be pursued, Argonne's design for RIA has aroused significant interest in the technological applications of the rare isotopes to be created. Two workshops on potential applications were held in 2000, and interest in the facility continues to grow. In addition to potential applications to research in materials science, biology, and medicine, RIA has an important national security role identified in the science-based stockpile stewardship program.

Argonne's concept for RIA is based on two accelerators. It uses a flexible approach for the primary production accelerator, which will be a high-power superconducting heavy-ion linac. The heavy-ion driver can deliver beams of any element from hydrogen to uranium, so a variety of production mechanisms can be selected to optimize rare isotope yields. One mechanism, heavy-ion fragmentation, can be used with a magnetic fragment separator and a new kind of fast gas catcher. This mechanism operates independently of the chemical properties of the exotic species being used. Argonne's approach to RIA also capitalizes on the capabilities of the Laboratory's existing state-of-the-art heavy-ion accelerator — ATLAS (Argonne Tandem-Linac Accelerator System) — as the postaccelerator.

ATLAS is unique in the world in its ability to provide intense, high-quality, continuous-wave (100% duty cycle), heavy-ion beams for all elements up to and including uranium. ATLAS has excellent transverse and longitudinal phase space properties, and it excels in beam transmission and timing characteristics. These capabilities are important for nuclear structure investigations and astrophysics experiments, where the beam quality requirements are especially stringent.

Preliminary estimates of effort, time lines, and cost suggest that this major new facility can be constructed at Argonne within about five years, following approximately two years of detailed facility design. A preliminary funding profile is specified in Table III.2. The profile assumes that DOE approves the mission need statement for the project in 2002 or early 2003. Funding is being sought from the Nuclear Physics (KB-02) program. A major challenge is to increase DOE's total nuclear physics budget sufficiently to allow RIA to proceed.

Table III.2 Rare Isotope Accelerator
(\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10
Costs									
Operating	2.8	3.5	11.0	5.0	3.0	13.0	31.0	45.0	63.0
Capital	-	-	-	-	-	3.0	10.0	15.0	20.0
Equipment									
Construction	-	-	-	27.0	85.0	140.0	216.0	186.0	114.0
Total	2.8	3.5	11.0	32.0	88.0	156.0	257.0	246.0	197.0
Direct Personnel	8.0	10.0	35.0	70.0	120.0	200.0	250.0	250.0	300.0

3. Functional Genomics

Recent developments in genome-scale DNA sequencing, high-throughput analytical tools, and computing technology have made feasible the genome-wide analysis of biomolecular function. Construction of a complete functional map of cellular behavior now appears to be achievable. Functional analysis of the thousands of proteins and other macromolecules needed for a comprehensive analysis of even the simplest prokaryote is a significant technological challenge that will require substantial enhancement of currently available experimental and computational capabilities. The amount of data needed to

functionally characterize an organism greatly exceeds that required to sequence its genome. Furthermore, unlike genome sequencing, functional analysis requires multiple high-throughput experimental technologies and novel computational approaches.

Nevertheless, the comprehensive characterization of biomolecular function has huge potential payoffs. It will provide the basis for developing entirely new strategies for modulating cellular activities and engineering novel cellular capabilities. These opportunities can provide the basis for novel solutions to problems associated with the DOE science mission, and they will be particularly important for advancing the DOE national security mission through the study of organisms used as biowarfare agents. More broadly, the resulting capabilities will enable major benefits for environmental management, human health, and general economic productivity.

To help seize these opportunities, Argonne is continuing a major Laboratory initiative to undertake the large-scale functional characterization of genomes and thereby advance the goals of DOE's Genomes to Life program. The Functional Genomics initiative comprises three components: structural genomics, high-throughput biochemistry, and bioinformatics. The structural genomics component will evolve from the crystallographic resources of Argonne's Structural Biology Center (SBC) — one of the best facilities in the world for collecting high-resolution data from crystals of macromolecules and macromolecular complexes. Meeting the needs of this initiative will require greater throughput at the SBC, which can be achieved by enhancing existing detectors and upgrading optics and robotics capabilities.

The high-throughput biochemistry component of this initiative will develop through the growth of facilities and capabilities originally created for the Midwest Center for Structural Genomics (MCSG; funded by the National Institutes of Health [NIH]). The MCSG has robotic facilities for high-throughput cloning, expression, and purification of proteins. Significant expansion of those robotic facilities will be required for production of proteins at a rate adequate for the Functional Genomics initiative.

The initiative's informatics component will encompass computational structural biology and development of novel genome and proteome databases that support high-throughput experimentation. Integrating the massive amounts of data to be generated by the Functional Genomics initiative with the vast amounts of data accumulating in public databases throughout the world will be a significant challenge in itself.

Argonne has sought input on the development of strategies and procedures for this initiative throughout the research community. In September 2001 Argonne hosted a workshop on the challenges of integrating genome and proteome databases. In November 2002 the Laboratory will hold a workshop on the use of structural genomics for functional analyses of macromolecules. Additional workshops addressing other aspects of the program are being planned.

This initiative will take advantage of a number of important existing resources at Argonne and the University of Chicago. The SBC at the APS will be key for the production of high-resolution images of gene products. Such high-resolution images are the best way to link the sequence information generated by genome projects to the functional data that will be generated by the Functional Genomics initiative. Resources at the APS and the IPNS will be used for small-angle scattering studies of macromolecular complexes (molecular machines) that will be identified by protein-protein interaction mapping and generated in high-throughput protein production facilities. Protein chips for the study of protein-protein interactions will be developed in cooperation with the Laboratory's biochip program (Section IV.A.2.f). Studies of gene expression will be carried out in partnership with biochip facilities at the University. Finally, Argonne computer scientists will create a computational environment for information management and for analysis and integration of functional data. Computer simulations are essential to the development of systems biology capabilities. The Functional Genomics initiative will include a major effort to advance the systems biology of prokaryotes by using simulation.

To develop comprehensive functional information on whole organisms, Argonne will both enhance its existing capabilities and establish

new capabilities. Existing resources for protein production will be enhanced. Novel resources for high-throughput mapping of protein-protein interactions will be established, as will facilities for identifying high-affinity, high-specificity ligands for all gene products and for the biochemical and biophysical characterization of protein function (e.g., enzyme assays). To house these resources, the Laboratory has proposed that the state of Illinois fund construction of a new facility providing over 40,000 square feet of laboratory space, including space for high-throughput crystallization facilities. To develop state-of-the-art intermediate-voltage cryoelectron microscopy and associated image processing capabilities, Argonne will partner with the University of Chicago. In general, the facilities developed for this initiative will serve the entire research community. They will provide researchers from universities and industry with a very broad range of capabilities needed to study molecular processes in the cell.

Argonne's Functional Genomics initiative is designed to advance the goals of the Genomes to Life program of DOE's Office of Biological and Environmental Research (DOE-BER). The four goals of this program are to (1) identify and characterize the molecular machines of life, (2) characterize gene regulatory networks, (3) characterize the functional repertoire of complex microbial communities in their natural environments at the molecular level, and (4) develop the computational capabilities needed to advance understanding of complex biological systems and predict their behavior. Key to this program is a systems biology approach to understanding how molecular machines and other cellular components function together in a living system. Developing capabilities for comprehensive functional characterization of entire genomes is critical to the success of this program.

Elements of Argonne's Functional Genomics initiative should attract sponsorship from NIH. Table III.3 describes the overall resources required, including the efforts of computer scientists, environmental scientists, and APS staff, as well as biologists working in the areas of structural and functional genomics. The increase in resources from FY 2002 to FY 2005 reflects anticipated expansion of computational and

Table III.3 Functional Genomics

(\$ in millions BA, personnel in FTE)^a

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating ^b	12.2	14.3	16.5	17.7	18.6	19.5	20.5
Capital Equipment	0.4	1.5	1.3	1.3	1.6	1.6	1.6
Construction ^c	-	-	2.0	16.0	16.0	-	-
Total	12.6	15.8	17.8	19.0	20.2	21.1	22.1
Direct Personnel	23.7	55.2	67.3	69.4	69.4	69.4	69.4

^aResource projections include funding from the National Institute of General Medical Sciences for the MCSG, plus anticipated funding from NIH, DOE-BER, and other organizations.

^bIncludes anticipated funding from NIH and the National Institute of General Medical Sciences for development of the GM/CA-CAT sector at the APS (enclosures, utilities, and undulators and other insertion devices).

^cFunding of construction has been proposed to the state of Illinois.

robotics capabilities and NIH funding to support sector development and operation of an experimental station (the GM/CA-CAT) at the APS. These increases will support multiple Argonne research divisions working — in the areas of computation, engineering, and molecular biology — to determine the molecular structure and function of macromolecular complexes. DOE funding will be sought from DOE-BES (Energy Biosciences; KC-03) and from DOE-BER (KP-11), including the latter office's new Genomes to Life program.

4. Petaflops Computing and Computational Science

Argonne's Petaflops Computing and Computational Science initiative builds on the Laboratory's existing long-term base program in mathematics and computer science, which is supported by DOE's Office of Advanced Scientific Computing. DOE and other agencies support work in the areas of mathematical software, parallel programming tools, advanced visualization systems, grid computing and distributed systems, collaboration technologies, scalable systems software, and performance analysis and modeling. Strong internal and external scientific collaborations tie this computer science research work to diverse applications in biology, high energy physics, climate modeling,

computational chemistry, chemical engineering, subsurface modeling, biomedical computing, astrophysics, and other areas. Argonne plans to continue building its base activities in fundamental computer science and mathematics while increasing its computational science efforts by applying advanced computing to leading-edge scientific investigations, both theoretical and experimental.

Argonne's Petaflops Computing and Computational Science initiative aims to accelerate progress in these directions through three major components: (1) a laboratory-wide computational science program, (2) a targeted R&D program, and (3) a new advanced computation building:

- The *Laboratory-wide computational science program* will provide expertise and midrange computing resources to the Laboratory. The purpose is to enable all research groups at Argonne to begin to apply state-of-the-art computational methods to their work and to help them prepare to take advantage of emerging large-scale computing opportunities. Current exploratory efforts involve all the Laboratory's scientific and engineering programs.
- The *targeted R&D program* will lead to deployment of a petascale system (i.e., one capable of 10^{15} operations per second) by 2006 and will include development of next-generation modeling capabilities in diverse scientific applications ranging from the life sciences and nanosciences to energy systems and the environment. The program will take advantage of the development of advanced analysis techniques for constructing predictive models of overall systems performance; recent advances in computer-aided design tools for applying an integrated software-hardware co-design approach to large-scale systems; and the expected availability by 2005 of the billion-transistor chips needed to build petascale systems.
- The *new advanced computation building* will support integrated research in mathematics, computer science, computational science and theory, collaborative research with industry, and joint programs with the University of Chicago (e.g., the Computation

Institute). The building will include a large-scale computer room capable of housing a petaflops computing system and will incorporate digital collaboration technologies to support distributed meetings and collaboratories.

During FY 2002 Argonne made substantial progress in several areas that support the Petaflops Computing and Computational Science initiative. A newly established collaboration with IBM's advanced architecture group has begun studying design options for specific classes of applications. A collaboration involving Argonne computer scientists and computational biologists and researchers at the University of Chicago aiming to advance large-scale computing in systems biology has begun to analyze model organisms and to design a whole-cell modeling system targeting petascale architectures. Laboratory researchers in computational nanoscience have begun development of an integrated simulation environment that combines models at multiple temporal and spatial scales; the researchers are also developing a virtual fabrication line simulation capability that will complement facilities being deployed in the Center for Nanoscale Materials (see Section III.A.1).

Resources required for the Petaflops Computing and Computational Science initiative are specified in Table III.4. Included are costs for facilities and for a concomitant increase in personnel (systems staff, postdoctoral researchers, scientific programmers, and permanent research staff). Funding will be sought from the

Table III.4 Petaflops Computing and Computational Science (\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	2.0	4.0	12.0	16.0	24.0	24.0	24.0
Capital Equipment	-	1.0	2.0	4.0	40.0	40.0	40.0
Construction ^a	-	-	-	4.6	4.6	4.8	5.0
Total	2.0	5.0	14.0	24.6	68.6	68.8	69.0
Direct Personnel	10.0	20.0	60.0	80.0	120.0	120.0	120.0

^aDetailed planning for the advanced computation building will be done in FY02. Calculation of construction costs assumes third-party financing for FY03 and FY04, with leasing to begin in FY05. The calculated leasing cost is based on 220,000 square feet at \$20 per square foot, plus overhead at approximately 1.15%.

Mathematical, Information, and Computational Sciences Division (KJ-01) and from other sponsors within DOE's Office of Science.

B. Energy

1. Advanced Nuclear Fuel Cycle

The need to produce increasing amounts of energy and still reduce the burden of energy production on the environment dictates that nuclear energy will have a major role in the future. Nuclear energy on the required scale cannot be realized without addressing problems associated with spent fuel disposition and nuclear nonproliferation. The best way to address those two problems is through an advanced nuclear fuel cycle that returns fuel to the reactor and produces a more benign waste form.

The requirement for an advanced nuclear fuel cycle is recognized in the May 2001 report of the National Energy Policy Development Group: "The United States should reexamine its policies to allow for research, development, and deployment of fuel conditioning methods (such as pyroprocessing) that reduce waste streams and enhance proliferation resistance." This need was also recognized more recently in the May 2002 summit meeting between President Bush and Russian President Putin. The two presidents agreed that their governments see promise in advanced technologies for nuclear reactors and nuclear fuels that would significantly reduce the volume of waste produced by civilian reactors, would be highly proliferation resistant, and could be used to reduce excess stocks of weapons-grade plutonium and other dangerous nuclear materials.

Argonne has been collaborating with DOE-Nuclear Energy, other national laboratories, industry, and international partners to formulate an Advanced Nuclear Fuel Cycle initiative. The initiative's objective is to develop the technology base for a new globally secure, sustainable nuclear regime that will allow nuclear power to become a publicly acceptable, growing part of the energy supply mix in the United States and abroad. Such a regime would also be marked by reduced and stabilized inventories of spent nuclear fuel, secure management of problematic nuclear materials,

enhanced proliferation resistance, and restoration of U.S. global leadership in nuclear technology.

Working with international partners, the Advanced Nuclear Fuel Cycle initiative would demonstrate the technologies and nuclear systems needed to bring about the desired new nuclear regime. The two key technologies and systems that must be developed and demonstrated are a closed, proliferation-resistant fuel cycle and an advanced fast-neutron-spectrum facility. Argonne proposes to develop and demonstrate a fuel cycle based on pyroprocessing and a fast-spectrum nuclear reactor.

The Laboratory's Advanced Nuclear Fuel Cycle initiative has four components: (1) oxide fuel reduction and actinide recovery, (2) the demonstration of reactor transmutation, (3) a prototype pyroprocessing facility, and (4) the design of a prototype reactor.

Oxide Fuel Reduction and Actinide Recovery

Pyroprocessing is now being used on a production basis at Argonne-West to treat spent fuel from the Experimental Breeder Reactor-II (EBR-II). However, the current system cannot process oxide spent fuel, nor can it separate and recover plutonium and higher actinides. Necessary advances are the development and demonstration of (1) a front-end process for reducing oxide fuel to metal suitable as input for electrorefining and (2) a process for recovering plutonium and other actinides for recycling into fast reactor fuel. Also required is completed qualification of the metal and ceramic waste forms for disposal in a repository. Those waste forms contain metals and fission products remaining after the separation and recovery of uranium, plutonium, and other actinides.

Demonstration of Reactor Transmutation

Demonstration of transmutation of actinides in a fast reactor requires fabrication of fuel containing actinides and irradiation of the fuel in a fast reactor to about 10% burnup. Such a demonstration will show that fuel containing actinides can be fabricated successfully in a remote process, that the fuel performs reliably in the reactor, and that the fuel has the necessary

inherent safety characteristics. With no fast reactor operating today in the United States, the demonstration will require international collaboration.

Prototype Pyroprocessing Facility

As the third component of this initiative, Argonne proposes to design, construct, license, and operate a prototype spent-fuel pyroprocessing facility. This facility would have a capacity of 100 metric tons of heavy metal per year for light-water-reactor spent fuel. The objective is to demonstrate the technical and economic viability of pyroprocessing and fabrication of new fuel containing recycled actinides, at a scale giving high confidence in the economic viability of a full-scale commercial plant.

Design of a Prototype Reactor

Finally, Argonne proposes to conduct nuclear system R&D and design studies focusing on a fast reactor of about 300 MWe power rating that incorporates lessons learned about fast reactor

technology from around the world, particularly lessons from Argonne's successful EBR-II program. International collaboration will facilitate the incorporation of worldwide lessons learned, and Argonne will seek partnerships with countries having significant experience with fast reactors and sustained interest in the technology, particularly Japan, France, and Russia.

Primary support for the Advanced Nuclear Fuel Cycle initiative will be sought from DOE-Nuclear Energy, Science and Technology (AF). Required resources are summarized in Table III.5.

Table III.5 Advanced Nuclear Fuel Cycle
(\$ in millions BA, personnel in FTE)

		FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs								
Operating	-	15.0	17.0	19.0	23.0	23.0	23.0	
Capital Equipment	-	5.0	8.0	10.0	5.0	5.0	5.0	
Construction	-	-	-	-	-	-	-	10.0
Total	-	20.0	25.0	29.0	28.0	28.0	38.0	
Direct Personnel	-	80.0	90.0	95.0	100.0	100.0	100.0	

IV. Science and Technology Strategic Plan

This chapter provides an overview of Argonne's strategic plan for research in science and technology. For Laboratory program areas, the chapter presents summary plans that describe strategies for accomplishing each program's objectives in the context of relevant issues and obstacles to be overcome.

Overall coordination of the Laboratory's planning with that of the Department of Energy takes advantage of key DOE planning documents — including the Department's overall strategic plan — that are being reformulated in 2002 to reflect current opportunities and priorities. Key documents available in early 2002 include the following:

- The national energy policy of the Bush administration, May 2001, a first step toward a comprehensive, long-term national strategy that uses leading-edge technology to produce an integrated national energy, environmental, and economic policy (URL: www.energy.gov/HQPress/releases01/maypr/energy_policy.htm).
- The annual budget request submitted by DOE to Congress (URL: www.cfo.doe.gov/budget/03budget/index.htm), including budget justifications for the Office of Science (URL: www.mbe.doe.gov/budget/03budget/content/science/sciexuc.pdf) and other DOE offices that support Argonne research.
- The *Strategic Plan* of the National Nuclear Security Administration.

Cooperation among the DOE laboratories, particularly through direct R&D collaborations, is increasingly extensive. This trend toward a more integrated laboratory system is described from an Argonne perspective in the Appendix.

A. R&D Area Strategic Plans

The balance of this chapter presents summaries of strategic plans for each of 19 planning units that span the Laboratory's major

mission areas (see the inset box on the next page). These strategic plan summaries are grouped into (1) fundamental science and national research facilities, (2) energy and environmental technologies, and (3) national security. This grouping encompasses DOE's four mission areas. In addition, a concluding summary plan addresses the crosscutting topic of collaborative R&D partnerships.

The planning areas for fundamental science and national research facilities correspond closely with Argonne's scientific divisions. In contrast, Argonne's technology programs cut across Laboratory divisions to exploit multidisciplinary capabilities. (See the Argonne organization chart at the end of this volume.)

A number of the R&D area plans that follow include discussions of program-specific initiatives. These discussions complement presentation of Argonne's major Laboratory initiatives in Chapter III.

1. Fundamental Science and National Research Facilities

Argonne's activities in the area of fundamental science and national research facilities are supported predominantly by DOE's Office of Science.

a. Advanced Photon Source

Situation

The Advanced Photon Source (APS) is Argonne's premier user research facility. Its ongoing successful operation is central to the Laboratory's outstanding performance in science and technology. Built and operated for DOE-Basic Energy Sciences (DOE-BES), the APS is delivering on its promise to serve the scientific community and to enhance U.S. productivity in a broad spectrum of scientific and technological areas. Over 4,800 individuals have qualified for

Argonne's Strategic Plans	
1. Fundamental Science and National Research Facilities	<ul style="list-style-type: none"> a. Advanced Photon Source b. Materials Science c. Chemical Sciences d. Nuclear Physics and the Argonne Tandem-Linac Accelerator System e. High Energy Physics f. Mathematics, Computing, and Information Sciences g. Intense Pulsed Neutron Source h. Biosciences
	<ul style="list-style-type: none"> i. Environmental Research j. Science and Engineering Education and University Programs
2. Energy and Environmental Technologies	<ul style="list-style-type: none"> a. Advanced Nuclear Technology b. Energy and Industrial Technologies c. Transportation Technologies d. Environmental Treatment Technologies e. Energy and Environmental Systems f. Biotechnology
3. National Security	<ul style="list-style-type: none"> a. Nuclear Nonproliferation and Arms Control b. Infrastructure Assurance and Counterterrorism
4. Collaborative R&D Partnerships	

badges to use the facility, and in 2001 nearly 500 publications were based on work performed there. International competition in this research area comes primarily from two similar synchrotron radiation centers, the European Synchrotron Radiation Facility in France and SPring-8 in Japan.

The APS began operating in 1996 as a user facility serving the worldwide community of x-ray researchers. Between 1989 and 1996, DOE invested \$812 million in construction of the APS and in R&D supporting construction. The resulting world-class photon source today provides the brightest x-ray beams available in the Western Hemisphere, for a wide range of research

fields such as materials science, structural biology, environmental studies, and applied engineering. Collaborative access teams — composed of investigators from private industry, universities, government, and other institutions — have committed an additional quarter billion dollars in capital investments for construction of APS beamlines. As of the summer of 2002, 28 of 34 available sectors have been assigned to collaborative access teams (CATs). (A sector comprises one bending magnet beamline and one insertion device beamline.) Included in these 28 sectors are 7 managed by Argonne staff: the Structural Biology Center (SBC) CAT, which comprises one sector; the Basic Energy Sciences Synchrotron Radiation Center (BESSRC) CAT, which comprises two sectors; and the Synchrotron Radiation Instrumentation (SRI) CAT, which comprises four sectors.

The SBC CAT is a national user facility for the study of macromolecular crystallography. It is funded through Argonne's Biosciences Division by DOE's Office of Biological and Environmental Research (DOE-BER). Designed for rapid throughput, SBC CAT provides users with the ability to collect data by employing standard crystallographic techniques and multiple energy anomalous dispersion phasing techniques.

The BESSRC CAT is a joint venture of Argonne's Chemistry and Materials Science Divisions, in partnership with the Geosciences program of DOE-Basic Energy Sciences (DOE-BES) and with Northern Illinois University. The two sectors of BESSRC CAT have been developed and instrumented for researchers in materials science, chemical science, atomic physics, solid state physics, and geosciences. Currently under development are plans for a dedicated small-angle scattering beamline and conversion of both insertion devices for use of tandem undulators. The center's existing high energy capabilities and its planned dedicated small-angle scattering facility will play important roles in the Center for Nanoscale Materials (CNM). (See Section III.A.1.)

The SRI CAT, supported through APS facility funding, focuses on developing instrumentation and techniques that utilize the unique properties of APS radiation to advance the frontiers of scientific research capabilities. Among the instruments and

capabilities that have already been developed are microbeam techniques, nuclear resonant spectroscopy, high-resolution inelastic x-ray scattering, coherence-based techniques, application of high energy x-rays, and generation and use of polarized x-rays. Microbeam techniques developed at the SRI CAT will provide an important foundation for the Nano CAT, which will be associated with the CNM. (See Section III.A.1.)

The APS provides users with 5,000 hours of beam time each year. During 2001, two major enhancements were implemented in the storage ring: top-up operation and reduced emittance. Top-up operation makes APS the only synchrotron facility in the world that operates in a constant-current configuration, which delivers to users an increased number of ampere-hours and also facilitates beam stability because of the constancy of the power loading on the storage ring and optical components. Reduced particle beam emittance translates directly into higher x-ray beam brilliance. Top-up operation and reduced emittance promise to increase the productivity of APS users substantially.

Vision

The APS will function in a highly reliable manner and will remain the preeminent source of hard x-rays for the U.S. research community into the foreseeable future, serving a wide range of frontier science and technology and addressing questions of importance both nationally and internationally. To maintain its preeminence and to continue highly reliable operation of accelerator and beamline systems, the APS will implement innovative accelerator enhancements that improve beam characteristics and state-of-the-art R&D that improves experimental capabilities. Through productive partnerships with its users, the APS will focus on opportunities to serve all its customers better, thereby creating a rewarding and enriching R&D environment and enhancing the facility's worldwide leadership role.

Mission

The mission of the APS includes the following three major elements:

- Delivery of world-class science and technology through operation of a state-of-the-art synchrotron radiation facility.
- Optimization of operational reliability, availability, beam quality, and scheduled operating time to achieve excellence in serving all research users.
- Development of leading-edge accelerator and experimental technologies that advance the research capabilities of investigators from across the United States and around the world.

Goals and Objectives

The overall goals of the APS are (1) to increase beam availability, beam quality, and scheduled operating time for both insertion devices and bending magnet sources and (2) to provide the technical and administrative support needed to maximize researcher productivity.

Major objectives are as follows:

- Maintain accelerator operations at better than 95% availability in 2003.
- Maintain operating time scheduled for users at 5,000 hours for 2003.
- Enhance the research capabilities available to users.
- Ensure accessibility of the facility to a broad spectrum of users.
- Provide essential services to APS users in the areas of technical support, operations, safety, administration, and general services.
- Optimize the scientific and technological benefits to society from research at the APS.

In all these endeavors, highest priority is given to ensuring the health and safety of employees, users, and visitors and to protecting the environment.

Issues and Strategies

The APS is currently processing applications from two prospective CATs planning research in the field of structural biology, more specifically in macromolecular crystallography. Agreements with both CATs are expected in 2002. The CATs will

be assigned the last two spaces available in the just completed laboratory/office module (LOM) 436, which was funded by the National Institutes of Health and DOE-Biological and Environmental Research.

Five additional prospective CATs are in various stages of writing proposals and raising funds: (1) Nano CAT, (2) Inelastic X-ray Scattering (ISX) CAT, (3) Midwest Center for Structural Genomics (MCSG) CAT, (4) Environmental (Enviro) CAT, and (5) the High Energy X-ray (HEX) CAT. Argonne staff members are playing leadership roles for all five of these prospective CATs. The missions of the five prospective CATs are as follows:

- Nano CAT will be associated with the CNM (see Section III.A.1). Nano CAT will provide the CNM with capabilities to characterize and study nanostructures through a variety of techniques.
- ISX CAT, a partnership among several national laboratories and universities, will be optimized for inelastic x-ray scattering at the APS. It will provide researchers with capabilities unique in the Western Hemisphere.
- MCSG CAT will be a high-throughput macromolecular crystallography beamline associated with the Midwest Center for Structural Genomics. It will focus on biostructures as they relate to structural genomics. (See Section IV.A.1.h.)
- EnviroCAT will provide beamlines dedicated to a wide variety of techniques valuable for environmental studies. Institutional members of the CAT include national laboratories and universities. (See Section IV.A.1.i.)
- HEX CAT is envisioned as a sector optimized for the use of high-energy x-rays, very penetrating radiation with a variety of applications to both basic and applied science. The capabilities of HEX CAT will complement those of Argonne's Intense Pulsed Neutron Source (IPNS). (See Section IV.A.1.g.)

Approval of these CATs is expected within the next few years, which will leave only one APS

sector uncommitted and available to serve new research programs. Two of the prospective CATs (Nano and MCSG) are associated with facilities proposed as part of major Laboratory initiatives. Buildings for both facilities, to be located in close proximity to the APS, will provide laboratory and office support for the associated CATs. However, no LOM exists to support the remaining prospective CATs. Funding is needed for the final LOM, to support sectors 27, 28, 29, and 30, so that the building will be available when it is needed by the CATs. Additional funding will also be needed to upgrade building services (e.g., heating and cooling) for new CATs.

The APS is a high-quality research facility with excellent, experienced staff. Although all the technical design parameters of its accelerator systems have been achieved, the facility's accelerator physics staff continues to focus on responding to ever-increasing user demands for the best possible operational reliability and availability. To remain at the scientific forefront and to maintain the excellence of its in-house research staff, the APS must continue to develop and meet technically challenging research objectives in accelerator physics, insertion device development, beamline design, optics R&D, and other areas. Beyond these technical challenges, APS currently faces the new administrative challenge of supporting operation of CATs funded by DOE-BES. The Laboratory is evaluating how best to balance this challenge with the need to maximize scientific productivity while maintaining the world-class in-house staff required to maintain the leadership role of the APS. Additional annual resources of approximately \$1.5 million per sector on average will be needed for the APS to assume responsibility for the BES-funded CATs.

Initiative: Enhancement of the APS and Development of Future Light Sources

Over the past three decades, the brilliance of x-ray sources has doubled every ten months. Use of coherent flux, which is directly proportional to beam brilliance, has had major unforeseen benefits for research in life sciences, soft condensed matter, and materials science, even though the flux values currently available at the APS are relatively low. To achieve the benefits

expected from future experiments at higher brilliance, it is imperative that planning begin now for a 10- to 100-fold increase in APS beam brilliance by 2006 (the tenth anniversary of facility operations). Such an increase in beam brilliance will require upgrading the storage ring and insertion devices. Maximizing gains in research productivity from the increased beam brilliance also requires improved beamlines, optics, and detectors.

To increase beam brilliance, R&D is needed on paths to higher currents, on techniques for further reducing particle beam emittance, on lengthening straight sections in the storage ring, and on upgrading insertion devices to better match future operational parameters of the storage ring, as well as on other problems. Upgrading an insertion device involves optimizing it for the particular scientific mission of a beamline, which requires R&D on undulator period optimization, on more extensive use of small-gap vacuum chambers, on in-vacuum and superconducting undulators, on development of nonplanar (figure-eight) devices, and on long insertion devices (for longer straight sections). Also required is aggressive study of how to tailor the storage ring parameters (i.e., beta functions, canted undulators, and straight-section lengths) for particular beamlines.

Design of many current APS beamlines began over a decade ago, and some already need upgraded components. Greater x-ray beam brilliance will heighten the need to upgrade beamlines. For example, mirror quality has improved enormously since the first beamline mirrors were ordered, and most of the mirrors currently installed will not be able to deliver to the sample a beam brilliance increased by two orders of magnitude. Other optical components will be similarly inadequate. Detector development is perhaps most urgent, and in many cases it is already on the critical path to faster data collection.

Now on the drawing board are what can well be called the second generation of beamlines for the APS. These highly specialized beamlines are being designed so that their radiation properties optimize a particular type of research, such as inelastic x-ray scattering, high-energy x-ray scattering, or nanoprobe applications. Develop-

ment of the second-generation APS beamlines presents new challenges to beamline scientists and engineers, and support for their efforts is needed if the APS is to remain at the forefront of scientific research.

Long-range plans are also being developed for other improvements to the APS storage ring that will enable it to lead the way into the next decade of x-ray science and technology. Argonne is developing concepts for further reducing the particle beam emittance by (1) operating the APS at a lower stored beam energy, (2) reconfiguring the magnetic lattice, or (3) using the existing booster and storage ring as the primary components of an energy recovery linac system to achieve a diffraction-limited, femtosecond x-ray source. Novel concepts such as these would create APS capabilities that are qualitatively and quantitatively different, and considerable R&D will be required to verify their feasibility.

In the late 1990s the Basic Energy Sciences Advisory Committee (BESAC) gave first priority to R&D on sources exploiting an 8- to 20-keV x-ray laser. Argonne has joined five partners — Brookhaven, Los Alamos, and Lawrence Livermore National Laboratories; the Stanford Linear Accelerator Center (SLAC); and the University of California at Los Angeles — to develop a proposal for a laser in the required wavelength range. Development of the proposed facility, the Linac Coherent Light Source (LCLS), will make use of the two-mile linear accelerator at SLAC and will take advantage of the distinctive capabilities of each of the partner institutions. Argonne has agreed to develop the integrated undulator systems for the LCLS. This work, which will account for about 20% of the total estimated project cost, will be funded separately from APS operations.

The original LCLS Scientific Advisory Committee, led by Gopal Shenoy (of Argonne) and Joachim Stohr (of Stanford University), gave BESAC a detailed proposal for pioneering experiments in atomic, molecular, plasma, and laser physics; in protein crystallography; and in nanoscale dynamics in condensed matter. Argonne researchers must start now to develop the optics, instrumentation, beamlines, and experimental techniques for the next generation of laser-based x-ray experiments if they are to lead the use of the

LCLS and remain at the forefront of synchrotron radiation research. For example, this unique facility will undoubtedly have major scientific impact in areas such as femtosecond time-resolved studies. The expertise needed for such studies should be developed now, so high priority should be given to a strong program of pump-probe studies using the APS with its current characteristics. Time-resolved studies, currently under way at the APS though in a nascent stage, should be expanded in scope and enhanced to improve temporal resolution, in order to fully exploit the unique science achievable through this largely unexplored field of study.

To begin exploring the physics and scientific applications of free electron lasers (FELs), the APS is examining the possibility of organizing the FEL CAT. Unlike other synchrotron-based facilities, FEL CAT would not use x-rays generated by charged particles in the synchrotron storage ring. Rather, it would use ultraviolet radiation generated by the low-energy undulator test line (LEUTL). Today no tunable laser systems of any sort operate in the wavelength range, below roughly 150 nanometers, that would be accessible to the proposed system. This very interesting wavelength range is today virtually unexplored by any tunable, high-power, pulsed laser system anywhere in the world.

Required resources are described in Table IV.1. Funding will be sought from DOE-BES (KC).

Table IV.1 Enhancement of the APS and Development of Future Light Sources
(\$ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10
Costs								
Operating	0.5	1.0	2.0	2.5	3.0	3.8	4.0	4.2
Capital	0.5	5.0	7.0	12.0	12.0	8.0	6.0	3.0
Equipment								
Construction	-	-	-	-	-	-	-	-
Total	1.0	6.0	9.0	14.5	15.0	11.8	10.0	7.2
Direct Personnel	2.0	5.0	7.0	9.0	11.0	13.0	15.0	15.0

b. Materials Science

Situation

Research in materials science at Argonne addresses critical issues underlying the development of new and improved materials that play crucial roles in both the national economy and DOE mission areas. The Laboratory's work embraces experimental and theoretical studies, as well as computer simulations. Argonne programs provide the fundamental understanding of novel materials that will underpin tomorrow's technologies. These programs emphasize the broad scale and depth of investigation that are possible within the national laboratories.

Argonne's user facilities for materials research feature prominently in Laboratory research programs. The Laboratory plays a leading role in developing the instrumentation and experimental design needed to apply its facilities to problems at the frontiers of materials science. Argonne programs stress collaboration with leading scientists at the Laboratory, across the nation, and around the world.

Key materials research areas at Argonne include superconductivity, magnetism, ferroelectricity, ceramic films, metals, carbon, biomaterials, and nanoscale materials science and technology. Crosscutting research themes are emphasized, especially complex oxides, interfaces, and defect production.

Vision

Argonne will foster world-class materials science, forefront instrumentation, and unique user facilities. The combination of individual freedom and teamwork that nurtured past successes will be strengthened. The Laboratory's contributions to new materials, especially at the nanoscale, will support both DOE and the nation in meeting new scientific, technological, and economic goals.

Objectives

Specific objectives of Argonne's research are as follows:

- Develop forefront programs in nanoscale materials science that explore the effects of confinement, proximity, and organization in magnets, superconductors, and ferroelectrics.
- Develop and apply innovative neutron scattering science to the investigation of materials, in preparation for the advent of the Spallation Neutron Source.
- Understand and exploit the rich diversity of behavior in complex materials, including oxides, polymers, biosynthetic composites, and carbon.
- Develop novel instrumentation that drives the frontier of science at the APS and the Electron Microscopy Center (EMC).

Issues and Strategies

Today is a time of high opportunity in condensed matter and materials physics. National attention on nanoscience has revealed new horizons for creating, understanding, and controlling novel behavior in materials arising from their nanoscale structure. Now within reach are grand challenges in materials fabrication by lithography and self-assembly, as well as in materials characterization using scanning probe microscopy, electron microscopy, focused x-ray scattering, and neutron scattering. Moreover, a complementary national emphasis on biology and medicine reveals many opportunities for adapting the traditional tools and ideas of materials physics to the study of genomes, proteins, and living cells. Qualitatively new materials and functionality can be created at the "hard-soft" interface between biology and condensed matter. All these directions are part of a general trend in materials physics toward increasing complexity. Exploiting this rich diversity of behavior will require new concepts and new approaches to integrating interdisciplinary experiments and theory in a comprehensive research program.

Argonne will take advantage of these unusual opportunities to strengthen its contributions to materials science. Creation of a new CNM (see

Section III.A.1) will extend the Laboratory's reach in materials science through development of fabrication facilities, a nanoprobe x-ray beamline at the APS, and new nanoscale characterization instruments. With other national laboratories, Argonne is developing a National Transmission Electron Achromatic Microscope (NTEAM) that will bring subnanometer spatial resolution and real-time response to a host of new materials experiments. The Laboratory is launching new programs in biosynthetic materials and spin-electronic materials and is teaming with other national laboratories to develop Centers of Excellence in Synthesis and Processing, in the areas of granular materials, permanent magnetism, ultrananocrystalline diamond, and ferroelectrics.

Argonne emphasizes excellent basic science as the cornerstone of its materials science program. The Laboratory continuously refreshes its program mix by adding new directions as new materials are discovered and research capabilities grow. Argonne stresses comprehensive programs that incorporate integrated experimental and theoretical thrusts and exploit advanced scientific instrumentation ranging from benchtop scanning probes to unique x-ray and neutron sources. The Laboratory regularly attracts outstanding international scientists as collaborators in its interdisciplinary programs. Leading theorists are attracted to the new Materials Theory Institute for stays of one week to six months that support key experimental programs. The resulting extensive professional network is invaluable as a source of intellectual stimulation and also as a source of outstanding candidates for postdoctoral and permanent positions.

Two important new directions in Argonne's materials science program are nanostructured biocomposite materials for energy transduction and spin-polarized oxides.

Argonne has launched an interdisciplinary program for the design, synthesis, and characterization of a new class of nanostructured biocomposite materials that exploit the capabilities of biological molecules to store and transduce energy. The goal is to organize complex biological molecules (e.g., light-harvesting proteins) into artificial host structures where the biological function can be optimized and exploited. An interdisciplinary team of materials

scientists, chemists, and biologists will use a novel lipid-based complex fluid and a rigid mesoporous inorganic framework as the host materials for biomolecules. This novel approach to nanostructured biomaterials that exploit biological functions has great scientific interest and enormous technological value. Research results are expected to provide fundamental insight into ways to use soft and hard materials to construct complex architectures that combine the functionality of biomolecules with the novel properties of host materials. This work will also provide fundamental knowledge of (1) nanoscale phenomena occurring at the interfaces between the integrated materials and (2) means to tailor energy transduction processes. Results could lay the groundwork for producing the next generation of materials for use in sensors, optoelectronics, artificial organs, and catalysis. This project will use major Argonne research facilities, including the APS, the IPNS, the EMC, the Advanced Computer Research Facility, and the planned CNM (see Section III.A.1). Also available for this project will be the facilities of the Center for Nanofabrication and Molecular Self-Assembly at Northwestern University. These major facilities provide unique capabilities for synthesizing and characterizing new biomaterials, as well as for understanding and tailoring their properties.

As the end of the silicon roadmap appears on the horizon, new kinds of electronics will be needed to meet the ever-increasing demands of information, energy, and national security technologies. Prominent among candidate approaches to sustaining the pace of progress is spin-electronics, or spintronics. In spintronic structures, information is stored and transmitted by using the spin of the electron, as well as its charge. Argonne contributes to fundamental understanding of materials issues affecting spin-polarized transport and develops ways of controlling and tailoring relevant materials properties. The central goal is to understand how the materials, their three-dimensional confinement into nanostructures, and their interfaces affect the generation and transmission of spin-polarized current. Pursuit of this goal will follow three parallel themes: (1) effects of confinement on phase behavior, (2) surface structure, and (3) interfaces and their impact on spin-polarized transport. This work builds on Argonne's expertise in the synthesis and

measurement of naturally layered manganites by creating artificially layered manganites that generate new spin-polarized oxide nanostructures. The work will be linked strongly with the APS, the EMC, and the IPNS, which provide unique scattering tools capable of revealing the new science underlying complex magnetic materials. The resulting fundamental knowledge of spin transport in complex oxides could enable development of the next generation of memory and logic devices.

User Facility: Electron Microscopy Center

Situation

Argonne's EMC provides transmission and scanning electron microscopy for high-spatial-resolution imaging, microanalysis, and *in situ* research. The EMC includes the Intermediate Voltage Electron Microscope (IVEM)-Tandem, which is used for a variety of *in situ* studies, especially for dynamic recording and structural characterization of the effects of ion irradiation. The IVEM-Tandem is the only facility in the Americas having this specialized capability, and it is employed by the international community. Qualified users access this facility by submitting written proposals that are peer reviewed. Nonproprietary research incurs no use charges. EMC users — including researchers from universities, other national laboratories, and industry — conduct studies ranging from imaging of electron-sensitive soft materials to *in situ* observation of phenomena at elevated and cryogenic temperatures in pure metals and alloys, semiconductors, and ceramics.

Other instrumentation in the EMC includes a state-of-the-art transmission electron microscope (TEM) with field emission gun and excellent analytical capabilities. Earlier acquisition of a scanning electron microscope (SEM) with field emission gun broadened surface analytical capabilities significantly.

Vision

The EMC will develop new techniques and methods, state-of-the-art instrumentation for TEM and SEM work, and capabilities for *in situ* studies. The materials research thus supported will provide

important new insights for major technologies in such areas as micromagnetics, irradiation effects in high-temperature superconductors, solid-state amorphization reactions, and analysis and control of nanostructures.

Issues and Strategies

Argonne's High Voltage Electron Microscope-Tandem Facility was decommissioned in FY 2001. The IVEM-Tandem, which retains the capability for *in situ* studies of ion beam irradiation, needs to be supported as a special national resource in materials research. Argonne is upgrading the microanalysis and image-recording capabilities of the IVEM-Tandem and has undertaken a new program to improve *in situ* experimentation based on new designs for holders and samples.

Initiative: National Transmission Electron Achromatic Microscope

Thanks to advances in aberration correction and quantitative-transmission electron microscopy, a new generation of electron microscopes can be built that are capable of sub-angstrom image resolution and sub-electron-volt spectroscopic resolution and that have space adequate for a variety of important experiments on advanced materials. To take advantage of these new technologies, Argonne has proposed the NTEAM. The required instrumental development could be carried out cooperatively at DOE's four national centers for electron beam microcharacterization, with each center contributing a complementary specialized facility based on a common platform.

The revolutionary combination of space and resolution envisioned for the NTEAM will allow the electron microscope to be converted into a true experimental materials science laboratory. Scientific impacts to be expected include the first three-dimensional atomic imaging of defect structures; the first atomic structure determination of a glass; microscopic understanding of magnetism and ferroelectricity in nanostructures; visualization of dislocation interactions in nanostructures under controlled stress; development of interface science to the level of surface

science; understanding of grain boundary motion under stress in nanocrystals; understanding of chemical reactions on highly curved, small catalyst particles; and imaging of defects in the oxygen sublattice of complex oxides. More generally, advances in electron beam microcharacterization associated with the development of NTEAM will be crucial for proper implementation of the planned national thrust in nanotechnology. The NTEAM project would also help to revitalize the critically important electron optics industry in the United States.

Following an international workshop held at Argonne in FY 2000, the Laboratory has pursued preliminary planning for an NTEAM instrument. A partnership of national laboratories is requesting permission to submit a formal proposal and is involving the research community in the planning. Seed funding from DOE is being used to advance designs for aberration-corrected microscopes. These efforts will also contribute importantly to Argonne's growing research in nanoscience.

c. Chemical Sciences

Situation

Chemistry is a core capability of the Laboratory. World-recognized research programs and staff with cutting-edge expertise study fundamental scientific questions critical to DOE's mission. Argonne research provides the foundations for addressing issues of energy independence, environmental sustainability, and national security and will underpin new technologies for energy efficiency, energy conversion, combustion, cleanup and disposal of radioactive and nonradioactive waste, and catalysis.

Vision

Argonne will enhance its status as a leading performer in chemical science research through sustained preeminence in established research focus areas and new multidisciplinary research challenges based on Laboratory core competencies.

Objectives

Specific long-range objectives of Argonne's core research in the chemical sciences are as follows:

- Advance understanding of the elementary chemical reactions and related nonreactive energy transfer processes involved in combustion by combining theoretical analysis of the energetics and dynamics of chemical reactions with experimental study of chemical dynamics and kinetics.
- Examine the chemical and physical properties of clusters of catalytically active transition metal atoms through combined experimental and theoretical studies that address, for example, how cluster properties evolve with size and how cluster chemistry depends on structure.
- Establish a refined, quantitative understanding of x-ray interactions with atoms and molecules to provide a fundamental basis for x-ray methods used in scientific investigations.
- Identify the mechanisms responsible for optimizing photochemical energy conversion in natural photosynthesis; use this information to develop artificial photochemical systems capable of enhanced photochemical energy conversion.
- Improve understanding of the initial physicochemical phenomena and molecular processes that occur when energetic radiation interacts with matter, through the use of pulsed-electron accelerators and very intense high-energy lasers causing excitation in the fastest time domains.
- Improve understanding of the interplay between f-elements and their environment through innovative experimental approaches, including laser-based methods such as (1) nonlinear laser spectroscopy, (2) optically detected nuclear magnetic resonance (NMR), and (3) *in situ* x-ray absorption fine-structure spectroelectrochemistry at the APS.
- Advance metal ion separations science by conducting fundamental investigations of the

interactions of metal ions with chelating agents and solvent molecules, by designing and characterizing new reagents for more effective separations, and by examining the physical and chemical characteristics of metal ion separation processes.

- Elucidate the important molecular and physical structural features of disordered carbonaceous materials — such as soots, heavy hydrocarbons, and coals — through use of state-of-the-art tools including synchrotron x-ray spectroscopy and scattering, neutron scattering, solid-state NMR spectroscopy and imaging, and laser desorption time-of-flight mass spectrometry.

Issues and Strategies

Argonne's core research programs in chemical sciences pursue their objectives by integrating special expertise with unique research tools and facilities. Staying at the forefront depends on developing novel experimental tools.

Current strategic initiatives have established the following important new research directions:

- Study, in real time, structural changes in short-lived reaction intermediates in photochemical processes by synchronizing x-rays from the APS with a laser pulse. Recent Argonne work has shown that a heme molecular mimic undergoes a structural change after interaction with laser light.
- Study charge thermalization and transport in polar and nonpolar liquids and solids by using the recently completed tabletop terawatt laser for ultrafast pulse radiolysis.
- Monitor particle aggregation and disaggregation in real time by using the small-angle x-ray scattering instrument at the Basic Energy Sciences Synchrotron Radiation Center at the APS. A high-resolution annular detector now under construction will enable *in situ* examination of soot particle formation in flames. This new capability will also benefit other areas of investigation, including the study of dynamic protein structures.

The following recent developments will affect the direction of Argonne's core research programs in chemical sciences:

- Increased understanding of the fundamental electronic nature of bond breaking was obtained by using photoelectron spectroscopy to probe the absorption of light and redistribution of the energy throughout a molecule. Vibrational autoionization of ammonia shows a profound preference for a single mode; this mechanism is expected to be active in a broad range of molecules.
- New catalysts are being developed that can be used in "green" solvents such as supercritical carbon dioxide, in order to reduce use of volatile organic compounds.
- A large multi-investigator study led by Argonne has demonstrated that the previously accepted value of the bond dissociation energy of water needs to be modified. This result will necessitate a cascade of changes to the values of many fundamental thermodynamic parameters tabulated for species and reactions containing OH.
- Reflectivity experiments on oxygen crystal truncation rods reveal a cyclic evolution of laterally ordered water molecules on a conducting RuO₂ surface. These results are important for understanding the interfacial electrochemistry of the electrolysis processes in fuel cells.

The chemical science goals in Argonne's major Laboratory initiative Center for Nanoscale Materials (see Section III.A.1). derive directly from the Laboratory's core expertise in areas including (1) the assembly of nanostructures from gas-phase clusters or fluidic phases, focusing on understanding the forces that drive aggregation and developing experimental and theoretical methods for controlling the assembly of nanostructures; (2) controlled reactivity in hybrid nanostructures, focusing on understanding and controlling photochemical, catalytic, and biological reactivity in bioinorganic hybrids and mesoporous structures at the nanoscale (an area in which the project Nano-Engineering the Biomolecule-Inorganic Interface for Integrated Photochemistry and Catalysis has been funded); and (3) information transfer between nano-

domains, focusing on understanding the principles by which the communication between nanoscale devices (sending and receiving) can be organized and controlled. Argonne's expertise in transient spectroscopies, x-ray synchrotron science, photochemistry, and theory, coupled with emerging expertise in scanning-probe microscopy, will be critical for understanding these phenomena. The Laboratory has initiated a program in nanophotonics for these studies.

Argonne's integrated program in the fundamental chemistry of radioactive waste is partly supported by the DOE Environmental Management Science Program. The Laboratory is uniquely qualified to undertake this program through its core capabilities in chemical separations science, heavy-elements chemistry, radiation chemistry, and theoretical chemistry, as well as through its facilities for research with radioactive materials (including the facility for actinide studies at the APS and the NMR facility designed for studying radioactive materials). This program of experimental and theoretical research responds to a national need for greater fundamental knowledge of the chemistry underpinning technologies for the cleanup and disposal of radioactive waste.

Argonne has developed two research programs in the chemical sciences in response to DOE's Nuclear Energy Research Initiative (NERI). One program focuses on (1) an innovative, single-material, minimum-volume approach to the selective sorption of most metal ion radionuclides from aqueous waste solutions and (2) the subsequent creation of a final nuclear waste form that is suitable for long-term storage or burial. In the other NERI research program, Argonne is studying radiation-induced corrosion relevant to the design of next-generation reactors. Higher energy efficiency can be achieved by operating pressurized-water reactors at pressures and temperatures well beyond those necessary for the formation of supercritical water. This work will consider the possibility of radiolytic water decomposition under such conditions.

Argonne is partnering with Northwestern University in the Institute for Environmental Catalysis. This partnership takes advantage of the Laboratory's expertise in magnetic resonance, pulse radiolysis, synchrotron research at the APS,

and heterogeneous catalysis. In addition, Argonne is a partner with Ohio State University in a second institute that focuses on the role of environmental molecular interfaces in the chemical and biological reactivity of pollutants. This collaboration will leverage Argonne's expertise in solid-state NMR, high-field electron paramagnetic resonance, and surface science.

Argonne has a new program in computational chemistry in response to DOE's Scientific Discovery through Advanced Computing initiative. In collaboration with Sandia National Laboratories and several universities, the program focuses on software for calculating and applying reaction kinetics and dynamics. This effort exploits the Laboratory's expertise in chemical dynamics, theoretical chemistry, and computer science and is part of the multilaboratory initiative Chemical Science Discovery through Advanced Computing: A Multi-Scale Collaboration. A second part of this program will develop the foundation for statistical methods and algorithms that provide internally consistent tables of active thermodynamic values.

d. Nuclear Physics and the Argonne Tandem-Linac Accelerator System

Situation

Review committees have consistently identified Argonne as one of the world's centers of excellence in nuclear physics research. The Laboratory's leadership role in planning the Rare Isotope Accelerator, the next-generation nuclear physics accelerator, will continue this tradition. The Argonne program has many strengths, including (1) low-energy heavy-ion physics, which is largely performed at the Argonne Tandem-Linac Accelerator System (ATLAS) facility (discussed below); (2) medium-energy nuclear physics, which emphasizes the use of lepton beams (at Fermilab, TJNAF [the Thomas Jefferson National Accelerator Facility], and DESY [Deutsche Elektronen Synchrotron]) as probes into the nuclear medium; (3) the study of relativistic heavy-ion collision dynamics by using beams from Brookhaven's newly commissioned RHIC (Relativistic Heavy Ion Collider); and (4) nuclear theory, which focuses on developing

fundamental understanding of hadronic and nuclear structure, reactions, and dynamics.

Vision

Argonne's nuclear physics program will resolve fundamental questions concerning the characteristics and dynamics of nuclear and subnuclear degrees of freedom in nuclei and nuclear matter. This work will involve continuous development of more powerful research apparatus and methods and the use of unique research facilities at Argonne and throughout the world.

Objectives, Issues, and Strategies

Argonne's work in low-energy heavy-ion physics will take full advantage of the unique capabilities of ATLAS to explore and understand nuclei at the limits of their stability: at high excitation energies, in exotic shapes, at rapid rotation, and with extreme proton-to-neutron ratios. Producing and detecting previously unknown isotopes and studying their structures can benefit greatly from secondary (radioactive) beams, which can provide access to regions of nuclei not currently accessible with stable beams. This approach will also allow laboratory study of key reactions in astrophysics and in the creation of the elements — reactions that occur in astrophysical settings and involve short-lived nuclei. To this end, Argonne is proposing a national Rare Isotope Accelerator that will be based largely on novel superconducting accelerator technology originally developed at the Laboratory and used for ATLAS. (See Section III.A.2.)

Argonne's work in medium-energy nuclear physics uses energetic lepton beams to increase understanding of quark and meson degrees of freedom in nuclei and the role of the quark-gluon structure of nucleons in shaping the character of nuclear forces. Laboratory researchers are playing a leading role in the research program at TJNAF, emphasizing the use of a general-purpose magnetic spectrometer constructed at the facility by the Argonne group. At DESY the Argonne group emphasizes use of a dual-radiator ring-imaging Cerenkov detector in the Hermes experiment to study the spin structure of the proton. In addition, the Laboratory is developing

new technologies in laser atom trapping of noble gas atoms for sensitive trace isotope analyses and for tests of fundamental symmetries.

Argonne's work in nuclear theory addresses the dynamics, structure, and reactions of (1) quark and gluon degrees of freedom in hadrons and (2) meson, nucleon, and nucleon resonance degrees of freedom in nuclei and nuclear matter. Using Argonne's massively parallel IBM and Chiba City computer systems and the National Energy Research Scientific Computing Center IBM SP, the Laboratory's nuclear theory group has set world standards for calculations of nuclear many-body problems in which it addresses fundamental questions in nuclear structure and nuclear astrophysics. The Argonne theory program provides important guidance for current and future experimental programs at ATLAS, TJNAF, and RHIC.

User Facility: Argonne Tandem-Linac Accelerator System

Situation

ATLAS is a DOE-designated national accelerator facility for research in nuclear physics that employs beams of low-energy heavy ions. The accelerator provides high-quality beams of all the stable elements up to the heaviest, uranium. A recently completed electron cyclotron resonance ion source has increased beam intensity by an order of magnitude. ATLAS is based on a technology developed at Argonne that employs superconducting radio frequency accelerator cavities. The ATLAS facility serves a broad community of about 300 users from more than 40 research organizations and universities.

Vision

The ATLAS facility will operate reliably and provide its national community of users with unique heavy-ion beams for research at the forefront of nuclear, atomic, and applied physics. Argonne will collaborate with U.S. industry to search for new applications of the superconducting radio frequency technology pioneered for ATLAS.

Objectives, Issues, and Strategies

The ATLAS program continues to optimize its operations and develop new linear accelerator technology to provide beams of higher intensity with excellent phase space and fast timing. Operational issues are reviewed continuously, and the facility's capabilities are frequently enhanced. Argonne will be investigating technical and research issues relating to acceleration of beams of short-lived nuclei, as a basis for proposing development of a Rare Isotope Accelerator based on ATLAS. (See Section III.A.2.)

e. High Energy Physics

Situation

Argonne performs cutting-edge research on the physics of elementary particles and develops the instruments and accelerators needed to make that physics accessible. This work in high energy physics leverages a range of diverse resources that generally are available only at a national laboratory. Argonne's program includes five experiments at different stages of preparation or data taking, a varied theoretical program, and R&D on advanced methods of particle acceleration potentially suitable for future research facilities.

Argonne researchers perform experiments at high energy accelerator facilities in the United States and Europe. Other experiments are performed in special laboratory facilities without accelerators. In all projects, special attention is given to collaboration with university groups. This collaboration encompasses joint work on detectors and detector subsystems, as well as support for students working on theses in association with Argonne staff members.

Vision

To deepen and extend understanding of the physics of elementary particles, Argonne will provide scientific leadership and will design and assemble major components of the required experimental systems. The Laboratory will choose studies in theoretical physics for relevance to the Argonne's experimental program or for general potential to advance understanding of interactions

between elementary particles. Collaboration with universities will be emphasized.

Objectives

Major objectives of Argonne's work in high energy physics are as follows:

- Maximize the output and impact of new physics generated from the Laboratory's experiments.
- Complete the demonstration of the Argonne Wakefield Accelerator and exploit the facility for further experiments in advanced acceleration technology.
- Advance the technology of high energy physics detectors by improving existing detector devices and inventing new ones.
- Improve theories of particle physics and expand understanding of experimental consequences.

Issues and Strategies

High energy physics experiments are conducted in most cases by large international collaborations. Increasingly, accelerator or collider facilities are unique and are not duplicated elsewhere in the world. Accordingly, Argonne's work in high energy physics is increasingly conducted at foreign accelerators, as well as those in the United States. Data taking in the ZEUS experiment at the German DESY laboratory began in 1992, and ZEUS continues to provide unique data from high energy electron-proton collisions. In 2001, a major luminosity upgrade was completed for ZEUS and related experiments, permitting a new focus on extreme values of kinematic variables where rates are low. Currently under way is fabrication work on a detector for the Large Hadron Collider (LHC), which is being constructed at the CERN Laboratory in Switzerland. Argonne researchers have established leadership roles in the ATLAS (A Toroidal LHC ApparatuS) detector, one of two major detectors planned for the LHC (and unrelated to the ATLAS facility located at Argonne). The U.S. government has a formal agreement with CERN that details the scope of U.S. participation in the LHC and the level of funding to be provided

by DOE and the National Science Foundation. Some work on the ATLAS detector will shift to preinstallation and installation activities toward the end of FY 2002. The detector is expected to begin taking data in 2006.

Argonne will be carefully considering expansions or new directions for many of its programs in high energy physics, in order to preserve their effectiveness in the next decade. Argonne researchers are playing leading roles in the MINOS (Main Injector Neutrino Oscillation Study) experiment, a long-baseline study of neutrino oscillation, employing a neutrino beam from the new Fermilab main injector. MINOS is now in the construction phase. The "far" detector is to be underground, adjacent to the current Soudan 2 detector in Minnesota. Argonne has primary responsibility for scintillator module construction at multiple sites and specific responsibility for developing and fabricating near-detector scintillator modules and front-end electronics. The Laboratory is also coordinating installation of the far detector at the Soudan Mine. First data from the detector are expected in FY 2004. A major upgrade of the CDF (Collider Detector at Fermilab) began taking data with the upgraded Fermilab Tevatron in 2001. Argonne's Wakefield Accelerator R&D program is now preparing for the second phase of its demonstration program; in order to explore ways of using this new accelerator technology in future experimental facilities, the Laboratory is discussing possible collaborations and alliances with researchers at other institutions.

The ATLAS detector at the CERN Laboratory in Europe is designed to solve the fundamental puzzle concerning the mechanism of electroweak symmetry breaking and the origin of mass. Calorimeter fabrication began in FY 1999 and must be completed by late FY 2002, when installation begins at CERN. Argonne is currently contributing to the design and prototyping of the trigger for ATLAS. System components will be built, tested, and commissioned during the coming five years. Development of the computing system for the ATLAS detector began as a new task in FY 2000 and became fully integrated with other U.S. work on ATLAS during that year. In collaboration with other U.S. and foreign ATLAS institutions, Argonne is taking the lead role in

developing core data management software, as well as calorimeter-specific software.

In theoretical high-energy physics, funding limitations have prevented the addition of junior researchers at appropriate intervals. With DOE, Argonne will explore means of adding one or more early career theorists, particularly in the area of neutrino physics.

Discussed below as programmatic initiatives are future efforts on the ATLAS detector software task and R&D toward a linear electron-positron collider and associated detector.

Initiative: ATLAS Detector Software Development

Provision of computing systems to support U.S. participation in the ATLAS detector at CERN's LHC was not addressed in the original combined LHC project agreement. This task includes the provision of computing, storage, and networking facilities in the United States to support simulation and analysis of ATLAS data by U.S. researchers, as well as software development by U.S. collaborators that will contribute to the overall ATLAS software system. Argonne, in cooperation with the University of Chicago, is leading the development of a major part of the software for which the United States has responsibility. The detailed work plan designates Argonne as the lead U.S. institution for development of a central database or database management software.

Resources required for work on ATLAS software are summarized in Table IV.2. Funding is sought from the High Energy Physics Program (KA-04).

Table IV.2 ATLAS Detector Software Development (\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	1.5	2.0	2.0	2.0	2.0	2.0	1.5
Capital Equipment	0.2	0.4	0.6	0.6	0.2	0.2	0.1
Construction	-	-	-	-	-	-	-
Total	1.7	2.4	2.6	2.6	2.2	2.2	1.6
Direct Personnel	7.0	10.0	10.0	10.0	10.0	10.0	7.0

Initiative: Linear Collider Accelerator and Detector Technology

In January 2002, a subpanel of the DOE-National Science Foundation High Energy Physics Advisory Panel gave highest priority to construction of a linear electron-positron collider in the energy range 500-1,000 GeV. This collider will complement the LHC by having sensitivity to a similar energy and mass range for new phenomena but qualitatively different measurement and identification abilities.

Success in building and exploiting this new collider depends on solving a number of design issues and choosing between two major accelerator technology alternatives, based on either warm or superconducting radio frequency cavities. Substantial R&D is also needed on the detector for the new collider, in order to optimize its ability to reconstruct events with the required precision. Argonne plans R&D on both the accelerator and the detector. For the accelerator, the Laboratory will use its world-class expertise in photocathode guns and electron beam optics. For the detector, the Laboratory proposes a new hadronic calorimeter technology based on resistive-plate chambers, which will be used with the energy flow approach to calorimetry being explored with the ZEUS detector.

Resources required for Argonne's work on this initiative are summarized in Table IV.3. Funding is sought from the DOE High Energy Physics Program (KA-04).

Table IV.3 Linear Collider Accelerator and Detector Technology (\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	0.2	0.5	0.8	1.0	1.0	1.0	1.0
Capital Equipment	-	0.2	0.3	0.3	0.3	0.3	0.3
Construction	-	-	-	-	-	-	-
Total	0.2	0.7	1.1	1.3	1.3	1.3	1.3
Direct Personnel	1.0	2.0	4.0	5.0	5.0	5.0	5.0

f. Mathematics, Computing, and Information Sciences

Situation

Many new scientific applications areas become tractable when computers operate at petaflops per second. These areas include computational biology and environmental science, multidisciplinary design, first-principles simulations in chemistry and materials science, and integrated modeling of Earth systems. Accordingly, the U.S. government has established the long-term goal of improving the large-scale computing systems needed for research and defense into the petaflops performance regime.

Developing and efficiently using petaflops computers by 2006 will require substantial advances in hardware, algorithms, systems software, and related enabling technologies. The hardware challenge alone is formidable. Although commodity clusters of computers have proved useful for large-scale scientific systems, such clusters appear to be incapable of scaling effectively to the petaflops regime. Instead, various point designs must be explored, such as cluster-on-a-chip technology and strategies involving integrated processors in memory or systems on a chip. Close collaboration with computer vendors will be critical to overcoming the hardware challenge.

Petaflops computing will also require a strong software infrastructure. Simple enhancements to existing software will not suffice. Researchers will need to explore new strategies, such as the co-development approach, which links development of systems software and compilers. Moreover, novel interfaces must be developed to integrate petaflops computing into the emerging national computational grids, and high-level tools will be needed so that users can quickly and seamlessly move applications from the workstation to a large-scale facility. A further major challenge will be the development of systems integration strategies that enable system scalability, from teraflops to petaflops, while still using the same hardware and software elements.

Vision and Goals

Computing science contributions at Argonne over the next five years will center on scalable computational resources, expertise in strategic applications areas, solutions to major scientific and engineering problems, remote sharing of instrumentation and immersive visualization facilities, and collaborative teams of computational and computer scientists.

Key to realizing this vision are world-class supercomputing and networking resources, complemented by world-class algorithms, tools, and software. The Laboratory will explore diverse avenues to achieving high performance, including scalable-cluster technology, distributed supercomputers, and teraops computer systems. The goal is to offer terascale computing, with an order-of-magnitude increase in bandwidth and a comparable decrease in latency.

Argonne researchers also will make seminal contributions to the software base for the next generation of problem-solving environments by addressing a wide range of challenges related to collaborative and distributed computing. Emphasis will be on open-source tools that make it easy for scientists to obtain codes, methods, and libraries and to work together in tackling large-scale scientific problems. In addition, Argonne will participate in large-scale joint ventures — such as the National Computational Science Alliance in the Partnerships for Advanced Computational Infrastructure — in order to research, develop, and validate the technologies needed to support applications scientists.

Objectives

Argonne has established the following specific objectives for its mathematics, computing, and information sciences program:

- Encourage Laboratory-wide strategic computational science applications that advance the frontiers of science in such areas as computational chemistry, computational fluid dynamics, and bioinformatics.
- Contribute importantly to the nation's enabling computing technologies by developing the software tools, distributed

computing, visualization, and numerical libraries needed to solve the most challenging scientific problems.

- Develop computational methods that enable better predictions in critical policy areas, such as climate modeling.
- Integrate efforts in advanced computation (including computer science, mathematics, and computational science) with experimental and theoretical research.
- Explore new technologies by anticipating needs and advancing the state of the art of large-scale computing in ways that make researchers more productive.

Issues and Strategies

Argonne researchers in mathematics and computer science continue to be at the forefront of scientific computing, leading efforts to develop new paradigms and technologies. One important area of work is distributed computing systems, where coupling of workstations and parallel computers, large databases, virtual-reality devices, and other resources worldwide promises tremendous advances in scientific problem solving. The Laboratory's aggressive pursuit of ways to enable distributed collaborative science applications includes (1) the Distributed Systems Laboratory, which is exploring computational grids for science and engineering, and (2) the Futures Laboratory, which is developing the Access Grid for collaborative tutorials and conferences.

The recent federal program Scientific Discovery through Advanced Computing offers increased funding for the computing sciences. Argonne researchers plan to make major contributions to this program by establishing national collaboratories and high-performance networks, developing centers for integrated software infrastructure, and performing fundamental research in computational science. Essential to the success of such efforts is access to world-class production and experimental computing facilities, as proposed in the major Laboratory initiative Petaflops Computing and Computational Science (Section III.A.4).

Argonne also proposes a major reorganization and expansion of its applied mathematics program

in response to objectives established by DOE's Office of Advanced Computing. Areas of investigation will include optimal control, multiscale modeling, and development of petaflops-class algorithms and technologies. In addition, major new thrusts will be initiated in such areas as data grids and collaboratories, modeling and analysis tools for molecular and cell biology, systems software and architecture research for petascale systems, and networking research test beds.

Progress in computer and communications technologies has set the stage for major advances in scientific problem solving. Argonne has a tremendous opportunity to contribute to these advances, but the opportunity will be lost without major investments in computational modeling and simulation. Critical to the Laboratory's efforts will be partnerships involving teams of computer scientists, computational scientists, and hardware developers from national laboratories, universities, and the commercial sector. This path is clearly the most effective one to an effective petaflops system that is balanced and addresses the needs of the many applications areas that can benefit.

g. Intense Pulsed Neutron Source

Situation

The IPNS has operated as a national user facility since its commissioning in 1981. Among DOE neutron sources, it has one of the largest user programs: in both FY 2000 and 2001, between 230 and 240 scientists conducted a total of approximately 400 experiments. Moreover, the IPNS is DOE's most cost-effective neutron source. Its high scientific productivity and cost-effectiveness have been noted frequently by national and international committees. In February 2001 that evaluation was reinforced by DOE's Basic Energy Sciences Advisory Committee (BESAC), which strongly recommended increasing annual IPNS funding by \$9 million in order to (1) improve the accelerator, targets, moderators, and available instruments and (2) expand the facility's research program. The IPNS currently provides 13 neutron scattering instruments, as well as facilities for studying radiation effects. IPNS operated for 25 weeks in

FY 2001, and it is scheduled to operate for 27 weeks in FY 2002.

Vision

The IPNS will function as a reliable and accessible user facility for neutron scattering research and as a successful developer of targets, moderators, and state-of-the-art neutron scattering instrumentation. Staff will help qualified users conduct world-class condensed matter research that addresses a wide range of questions important to both science and technology. Through enhancements, the IPNS will maintain leading-edge capabilities in neutron scattering. Through expanded collaboration with other Argonne facilities, such as the APS and the CNM (Section III.A.1), the IPNS will further increase its scientific productivity.

Issues and Strategies

The IPNS has historically been severely oversubscribed, understaffed, and underfunded. The additional \$4 million in IPNS operating funds included in DOE's Scientific Facilities Initiative beginning in FY 1996 now allows approximately 25 weeks of operation per year, with a full complement of instruments serving users. A 16% increase in FY 2002 operating funds from DOE, along with an anticipated 7.5% increase in FY 2003, will enable the IPNS to begin work toward enhancing its instruments. Improved instruments are expected to attract about 70% more users each year, or 400 rather than 240.

Neutron scattering in the United States will be in a state of flux for the next decade. Currently, two DOE facilities and a facility of the National Institute of Standards and Technology (NIST) provide neutrons: the IPNS, the Los Alamos Neutron Science Center (LANSCE) at Los Alamos National Laboratory, and the NIST Center for Neutron Research in Gaithersburg, Maryland. A major upgrade of the High Flux Isotope Reactor (HFIR) facility at Oak Ridge National Laboratory is currently under way, and construction of the 1-MW world-class Spallation Neutron Source (SNS), also at Oak Ridge, is scheduled for completion in FY 2006, with full user access scheduled for FY 2008. Consequently, over the next six years the IPNS will evolve from a major

national source of neutrons for U.S. users to a medium-sized regional facility. In this environment, the role of the IPNS will be increasingly coupled to the APS and the CNM.

The role of the IPNS over the next decade in serving neutron scattering researchers and the broader scientific community is best described in terms of short-, medium-, and long-term strategies.

Short-Term Strategies (Next Three Years). The IPNS role in the early transition period is to promote growth in the U.S. neutron user community and to support the SNS project so that world-class instruments and a responsive user program are in place when that new facility is commissioned. The IPNS also must begin positioning itself for highly productive research after the SNS starts operations. These goals can be achieved through the following actions:

- Institute incremental accelerator and source upgrades, and increase the number of IPNS users during a year from 240 to 400.
- Improve IPNS instruments so as to build the facility's user base and more effectively train neutron users.
- Host the SNS instrument development team. Test SNS instrument concepts, components, data acquisition systems, and detectors.
- Contribute to the SNS project where appropriate, in the areas of target, moderator, accelerator systems, and user programs.
- Conceptualize SNS instrumentation capable of serving frontier scientific experiments in the coming decades.
- Leverage the full range of capabilities available at the CNM, the APS, and the IPNS in order to better serve facility users.
- Create joint staff appointments between the IPNS and the APS, the CNM, and the University of Chicago.

Medium-Term Strategies (Three to Seven Years). Just before SNS operations begin, the IPNS role will be to begin development of the next generation of SNS instrumentation and to operate the IPNS with upgraded instrumentation that better supports the neutron scattering

community. Closer ties with the APS and the CNM will facilitate more effective utilization of neutrons and photons to investigate fundamental issues in science and technology. These goals can be achieved through the following actions:

- Continue to operate the IPNS in a very effective manner (at 95% reliability).
- Give priority to development of IPNS instruments that will be capable of world-class science after SNS startup.
- Within the IPNS, strengthen expertise for nanoscience characterization.
- Begin the design and construction of up to four SNS instruments.
- Further strengthen scientific ties to complementary U.S. facilities, starting with the APS and the CNM at Argonne. Establish further joint staff appointments with those Laboratory facilities.
- Continue leading U.S. improvements to accelerator and target/moderator operations for neutron sources.
- Develop software and methods that support remote data access and control of experiments using the Internet.

Long-Term Strategies (beyond Seven Years). After FY 2008 the U.S. neutron scattering landscape will be significantly different from today's. The brilliance of the SNS and its world-class instrumentation will make that new facility especially well suited for parametric studies and studies of very small samples. The IPNS will become a regional facility supporting both fundamental research and the development of instruments, optical devices, and detectors for neutron sources. The IPNS will be especially useful for speculative or exploratory experiments and for investigations in scientific fields where combining photon probes and neutron probes is important, such as nanotechnology, soft-matter studies, and research on magnetic materials. In addition, Argonne will work toward full instrumentation of the SNS high-powered target station and will play a lead role in building the Long Wavelength Target Station at the SNS.

These goals can be achieved through the following actions:

- Commission and operate selected neutron scattering instruments at the SNS by utilizing the instrument development team concept developed by the SNS.
- Continue collaboration with Argonne research partners and with university scientists to give users the tools best suited to their fundamental research, whether located at the IPNS, the SNS, or the APS.
- Leverage complementary assets within Argonne and across the DOE laboratory system — including the IPNS, the CNM, the APS, the SNS, and the HFIR — to best serve the missions of DOE and other research sponsors.
- Provide leadership for U.S. efforts aimed at developing improved neutron optics and detectors.
- Lead the design and construction of the Long Wavelength Target Station at the SNS.

Initiative: IPNS Enhancement

Under the IPNS Enhancement initiative, Argonne proposes to improve existing instruments significantly (increasing data rates by factors ranging from 2 to 32) and to increase the number of weeks of operation to enable an expanded user community to gain experience at a pulsed source in preparation for using the SNS. These additional operations and scientific capabilities were detailed in a plan presented to the November 2000 meeting of the BESAC subpanel reviewing operations at LANSCE and IPNS. In February 2001 the Argonne plan became the first of the subpanel recommendations approved by BESAC.

Work on equipment under the IPNS enhancement plan falls primarily into (1) accelerator upgrades and spare parts, (2) improvement to the moderator and reflector, and (3) instrument enhancements:

1. Reliability will be maintained above 95% by upgrading aging accelerator systems and obtaining spare parts in FY 2002. In addition, a 30% increase in neutron production will be achieved through utilization of secondary

harmonic technology in the accelerator system.

2. Judicious choice of replacement materials can improve neutron yield by a further 20%. This work is currently scheduled for 2003.

3. The performance of all IPNS instruments can be increased significantly through various enhancements, such as more detectors, better data acquisition systems, neutron guides, and new ancillary equipment. Implementation of these enhancements over the next four years will improve data rates by factors as great as 32, allowing many IPNS instruments to be competitive with those at the world's best pulsed neutron source, ISIS in the United Kingdom.

Resources required for the IPNS enhancement initiative are summarized in Table IV.4. Funding will be sought from DOE-BES (KC-02).

Table IV.4 IPNS Enhancement
(\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	1.6	2.6	3.6	4.6	5.3	6.0	6.8
Capital Equipment	0.6	1.8	2.3	2.0	1.0	-	-
Construction	-	-	-	-	-	-	-
Total	2.2	4.4	5.9	6.6	6.3	6.0	6.8
Direct Personnel	6.0	8.5	11.0	13.5	13.5	13.5	13.5

h. Biosciences

Situation

The sequencing of the human genome is approaching completion, and over 200 other genome sequences are either completed or in process. With these accomplishments, biology has reached a turning point at which complete enumeration of the genes used by an organism is within reach. The challenge now is to interpret this information to construct a detailed, coherent, complete view of living organisms and to use this view to develop powerful methods for manipulating and engineering biomolecular systems and predicting their responses to environmental stimuli. The key to such detailed control of biomolecular systems lies in a complete

mapping of the activities of the gene products of a cell that cooperate to perform all cellular processes. The information required to characterize these processes is embedded in the spatiotemporal distribution of gene products and metabolites across multiple length scales.

In coming years, progress in the biological sciences will depend increasingly on interdisciplinary interactions with computational, physical, chemical, and materials scientists. Implementation of high-throughput techniques for biochemical and biophysical characterization of biomolecular systems will make it possible to address experimental challenges that are now unbroachable. Huge volumes of data will be required. Cataloging and preserving those data and then extracting maximum information will present a significant challenge in database design and maintenance. In the longer run, integrating the data into a complete view of cellular (and, ultimately, organismal) behavior will require novel approaches to simulating complex systems. Computation will come to dominate the biological sciences in the 21st century. This approach to genome-scale analysis of biological function, now widely referred to as systems biology, involves the fusion of functional genomics with high-end computational simulations of the molecular behavior within biomolecular systems.

Vision and Goals

Argonne will move toward a leadership position in postgenomic biology by creating a model program for the comprehensive functional analysis of genomes. The Functional Genomics initiative (see Section III.A.3) will take advantage of the Laboratory's strong programs in the physical, chemical, materials, and computational sciences to build, along with biosciences, a uniquely interdisciplinary program for post-genomic biology. Partnership with computational scientists will develop a systems biology capability that will be well positioned for the comprehensive analysis of the behavior of microorganisms that are relevant to DOE's science mission.

Experimental facilities at the APS and world-class computational resources will be integral parts of Argonne's program for genome-wide

structural and functional characterization of organisms — a program that will be centered around the Laboratory's quickly growing effort in structural and functional genomics. Revolutionary approaches to currently intractable problems will be explored in collaboration with Argonne physicists, chemists, and engineers. Programs in bioinformatics, nanobiotechnology, and combinatorial biology will engage scientists at both the Laboratory and the University of Chicago. The goal is a focused program aimed at developing and using high-throughput experimental and cutting-edge computational capabilities for the complete functional characterization of whole genomes.

Objectives

Argonne's Functional Genomics initiative will grow around the Laboratory's current structural and functional genomics programs by taking advantage of both resources supporting the current program and other resources at the APS and across the Laboratory. The initiative will greatly strengthen cross-disciplinary interactions aimed at creating revolutionary approaches to currently intractable problems.

Argonne's major objectives in biosciences are focused on its major Laboratory initiative, Functional Genomics (Section III.A.3), elements of which include the following ongoing and novel efforts:

- *Structural Genomics.* Develop a scientific program aimed at deepening understanding of the relationship between protein structure and function — a program centered on current efforts to characterize to atomic resolution the three-dimensional structure of all gene products and to use that structural information to develop better understanding of the function of each gene product.
- *High-Throughput Protein Production and Crystallization.* Argonne's current use of robotics for high-throughput expression of proteins will provide milligram quantities of hundreds of proteins for functional analysis. In parallel with crystallization efforts, these proteins will be analyzed by using functional proteomics, combinatorics, and small-angle x-ray diffraction. The robotics expertise of

Laboratory scientists will be exploited to develop techniques for high-throughput biochemical and biophysical analyses. Upgraded robotics capabilities for the rapid and efficient production of diffraction-grade crystals of biological macromolecules will eliminate the most severe bottleneck in the Laboratory's structural genomics work.

- *Revolutionary Approaches to Membrane Protein Crystallization.* The 30% of proteins that are integral components of cellular membranes cannot be investigated by using the techniques that are successful in crystallizing other proteins. In collaboration with physical and chemical scientists, Argonne will explore revolutionary approaches to the crystallization and biochemical analysis of these proteins.

- *Program for Combinatorial Biology.* Mapping of protein-protein and protein-ligand interactions is one of the most powerful methods for the functional analysis of macromolecules. A comprehensive program in combinatorial biology is being developed to take advantage of the huge potential of this approach for the functional analysis of whole genomes. Furthermore, a program for the high-throughput production of affinity tags will be developed to aid in the purification and functional analysis of gene products. This program will use combinatorial libraries of proteins and peptides displayed on the surfaces of viruses and bacteria and will screen these libraries for desired functionalities.

- *Program in Nanobiotechnology.* Argonne materials scientists and biologists will cooperate to develop a new program in nanobiotechnology that will explore the creation of bio-inspired nanostructures and bio-compatible materials, as well as the structural analysis of complex biological materials.

Issues and Strategies

Argonne is uniquely positioned to take advantage of the extraordinary opportunities developing in postgenomic biology. Through multidisciplinary collaborations among scientists

across the Laboratory and at the University of Chicago, Argonne will seek leadership in newly defined areas of the biological sciences and will explore revolutionary approaches to a number of currently intractable problems in structural and cellular biology.

The core of Argonne's bioscience efforts is work in structural genomics to establish high-throughput macromolecular crystallography and its use for enumerating all existing protein structural motifs. This work has motivated initiatives in high-throughput crystallization of macromolecules and high-throughput expression of proteins in bacterial hosts. Building on the Laboratory's existing robotics expertise, these initiatives will provide a further base for developing robotics for rapid biochemical and biophysical assays of protein structure and function. Argonne's existing structural genomics efforts are tightly focused on crystallographic studies, and augmentation in the indicated directions is a priority.

In general, development of new interdisciplinary interactions across the Laboratory and with the University of Chicago will drive Argonne's planned initiatives in the biosciences, where DOE and the National Institutes of Health (NIH) will be major funding sources. The Functional Genomics initiative (Section III.A.3) directly addresses the goals of DOE's new Genomes to Life program. In addition, important funding from the state of Illinois is being sought to enhance the planned program in high-throughput protein production and crystallization. A key complementary strategy is development of cooperative agreements with biotechnology companies for joint development of novel methodologies.

Argonne initiatives in the biosciences will build from four parallel and complementary efforts in macromolecular crystallography that are currently being pursued: (1) The capabilities of the existing DOE-funded Structural Biology Center are being enhanced significantly through support from NIH. The Midwest Center for Structural Genomics will receive from NIH approximately \$5 million per year for development of high-throughput macromolecular crystallography. (2) In partnership with this effort, Argonne is also working with NIH to develop a

second APS sector for macromolecular crystallography. (See Section S1.C for discussion of these NIH-supported efforts.) (3) To facilitate this work, a laboratory complex for biostructure research has been constructed at the APS with joint DOE and NIH funding (see Section IV.A.1.a). (4) Argonne is also working with the state of Illinois on plans to construct an Accelerated Protein Production and Crystallization Facility at the APS, which is to include development of an additional APS sector for structural genomics and macromolecular crystallography. Close partnerships among these four efforts will enable significant economies of scale, facilitating rapid improvement in the understanding of structure and function in proteins.

Around these significant efforts in structural and functional genomics and crystallography, Argonne is building its Functional Genomics initiative. Research on genome-wide analysis of the structure, assembly, and operation of gene products is greatly expedited by the use of large-scale, high-throughput capabilities for analyzing intermolecular interactions and other biochemical and biophysical parameters of macromolecular complexes. This initiative will establish the resources needed for comprehensive studies of biomolecular machines, interface this effort with the Laboratory's ongoing work in structural genomics, and use the resulting capabilities to characterize the molecular machines critical to cellular processes in all organisms.

i. Environmental Research

Situation

Environmental issues continue to be a leading national concern, reflecting population growth, economic development, and the environmental legacy of past activities and practices. The focus is shifting from effluent control technologies and associated regulation toward waste and resource management, site remediation and long-term stewardship, facility decontamination, and global environmental issues. Basic and applied research leading to more cost-effective environmental technologies and practices is increasingly important. Moreover, new technology and information — such as geographic information

systems, computer imaging, and satellite survey data — have created opportunities to address hitherto intractable environmental problems.

Vision

Argonne will provide national and international leadership in key areas of environmental research by developing innovative and cost-effective solutions to high-priority environmental problems, such as carbon cycling and carbon sequestration, climate change and air quality, biogeochemical cycling, and improved site characterization and remediation. Laboratory researchers of recognized professional standing, complemented by state-of-the-art facilities and instruments, will address problems at the frontiers of environmental science that are technically challenging, broadly relevant, and unlikely to be resolved in a timely fashion through private-sector R&D alone.

Objectives

Central objectives of environmental research at Argonne are as follows:

- Make significant, growing contributions to three environmental grand challenges: (1) biogeochemical cycling, (2) atmospheric particulates and aerosols, and (3) a hydrogen-based energy system.
- Develop synchrotron-based techniques for molecular environmental science, based on the high-brilliance x-rays of the APS.
- Develop fundamental studies of soil carbon characterization and transformation in order to understand and quantify carbon sequestration as a method for controlling atmospheric carbon dioxide levels.
- Further expand the Atmospheric Boundary Layer Experiments (ABLE) site as a facility generating data required for research on climate change, including the exchange of carbon and water between the atmosphere and terrestrial ecosystems.

Issues and Strategies

Argonne has significant core capabilities in bioprocessing; ecology; modeling and measuring environmental pathways; atmospheric physics and chemistry; developing “clean” technologies; control and remediation technologies; and development of decision models for rapid, cost-effective remediation of DOE sites. This foundation provides important opportunities for fruitful integration of applied environmental studies with fundamental capabilities in physics, chemistry, biology, and mathematics. Building on this foundation, the Laboratory plans to establish broad, multidisciplinary research teams for large-scale studies in environmental science.

Cost-effective resolution of the important environmental issues facing DOE, the nation, and the world requires the integrated application of multiple scientific disciplines. Argonne believes that the future of environmental research at the national laboratories lies in increased emphasis on basic and applied research conducted by multidisciplinary teams able to exploit fully major research facilities and other unique capabilities. Better solutions to environmental problems can be achieved both by expanding the knowledge base and by applying what is already known more effectively. The initiative Grand Challenges in Environmental Science at the end of this area plan expands on this theme.

In the area of atmospheric science, Argonne is building on its existing capabilities in atmospheric science, remote sensing, advanced computation, information processing, and important observational efforts in climate change, atmospheric chemistry, carbon cycling, and hydrology. Facilities are managed with the overall objective of making available to all qualified users continuous, long-term observations from state-of-the-art instruments distributed over a large area in a meteorologically important region of the country and thereby to create a key national asset for progress in atmospheric and hydrospheric research. Data from Argonne’s ABLE site contribute to DOE’s AmeriFlux (carbon flux) and Environmental Meteorology research programs and to the National Aeronautics and Space Administration’s land surface hydrology program. The ABLE site is now also the study site for a

pilot program demonstrating DOE's capabilities in a new national Water Cycle Initiative.

At the end of FY 2000, Argonne assumed responsibility for operations and oversight for all three Cloud and Radiation Testbed facilities of the DOE-BER Atmospheric Radiation Measurement Program. The Laboratory's operating resources for Environmental Processes (see KP-12 in Chapter VI) now include substantial DOE funding for redistribution to other national laboratories, universities, and subcontractors.

Argonne conducts research for the Atmospheric Chemistry and Environmental Meteorology components of the DOE-BER Atmospheric Sciences Program and provides the lead scientist for Atmospheric Chemistry. The Laboratory participates in collaborative field campaigns that gather information on the sources and fates of oxidants and particulate matter in the lower atmosphere and on associated meteorological processes. Associated DOE research addresses numerous scientific challenges regarding the effects of energy-related trace chemicals on local and regional air quality and on climate. The work at Argonne emphasizes dry air-surface exchange, which affects the budgets of chemicals in the lower atmosphere; chemical transformations leading to oxidant and particle formation; and physical processes that transport materials vertically and horizontally in the lower one or two kilometers of the atmosphere.

The central goal of Argonne's work in synchrotron-based environmental science is an atomic- and molecular-level understanding of structure and processes in environmental systems. One set of studies considers mineral-fluid interactions and the mechanisms by which contaminant elements become bound to mineral surfaces. Other studies focus on developing synchrotron-based imaging techniques for environmental and biological samples and on understanding the speciation, binding, distribution, and mobility of heavy metals and radionuclides in soil-fluid-biota systems. These multidisciplinary efforts build on the Laboratory's widely recognized research at the forefront of molecular radiation science and environmental science and involve several new internal and external collaborations. See the focused initiative

Synchrotron Environmental Science at the end of this area plan.

Argonne is building and strengthening ongoing programs in site characterization and soil ecology. The Laboratory continues its R&D on environmental tools such as QuickSite®, a methodology that has become the basis for the American Society for Testing and Materials standard for expedited site characterization.

In the area of soil ecology, studies are under way on the importance of soils in sequestration of carbon dioxide and, in conjunction with the synchrotron-based environmental research, on the molecular-level processes that result in soil aggregation.

Argonne is participating in two new research centers at the University of Chicago that have grown from long-standing collaborations. The Joint Argonne-University of Chicago Center for Environmental Science will investigate the effects of urbanization and regional climate variability on human health, while the Center for Integrating Statistical and Environmental Sciences will develop innovative statistical methods and approaches for analyzing and validating environmental data.

Initiative: Grand Challenges in Environmental Science

Numerous diverse research activities conducted throughout the Laboratory have significant environmental benefits or applications. By integrating the underlying expertise via collaboration among multidisciplinary teams, Argonne aspires to increase its impact on three nationally recognized environmental "grand challenges" that match the Laboratory's capabilities — both expertise and facilities — particularly well: (1) biogeochemical cycling, (2) atmospheric particulates and aerosols, and (3) the transition from a hydrocarbon-based economy to one based on hydrogen.

In biogeochemistry, central goals are (1) to quantify the rates of transfer of compounds to and from storage reservoirs (implying accumulation and depletion) and (2) to determine the mechanisms controlling these transfers. The most important challenge is to understand how Earth's major biogeochemical cycles are perturbed by

human activities; to predict the impact of these perturbations on local, regional, and global scales; and to determine how these cycles could be restored to more natural states. Argonne teams will focus on primary and secondary interactions between the multiple elements of these problems and on the associated positive and negative feedbacks. Studies will range from the atomic level to bench scale to field scale.

Atmospheric particulates, both natural and anthropogenic, are inextricably linked to energy production and use. Such particles have significant detrimental effects on human health, play a major role in acid rain formation, and have direct and indirect radiative forcing effects that are comparable in magnitude to the effects of greenhouse gases but of opposite sign. The characteristics, distribution, and transport of such particles over long distances affect issues ranging from national security (e.g., transport of harmful spores) to general air quality (e.g., atmospheric chemical interactions). Argonne research will determine how atmospheric particles are formed, their roles in global and regional climate systems, and their relevance to chronic and acute respiratory diseases. Approaches based on materials science, chemistry, and physics are particularly appropriate for these studies.

Argonne is well positioned to investigate the potential effects of a shift from a hydrocarbon fuel infrastructure to one based on hydrogen fuel. The Laboratory can help to understand, predict, and mitigate the environmental consequences of this shift. The Laboratory's capability to study hydrogen production is particularly outstanding. Questions to be addressed will include effects of atmospheric emissions on tropospheric and stratospheric hydroxyl radical concentrations, changes in stratospheric ozone, and resulting effects on urban areas. These studies can take advantage of Argonne's strong engineering capabilities in the nuclear generation of hydrogen and in novel approaches to environmental control technologies.

This effort fits within the scope of the U.S. Global Change Research Program's FY 2003 initiative in climate change, a likely near-term source of funding. Other programs that would benefit from Argonne's pioneering approach to multidisciplinary integrated research are DOE's

Genomes to Life program and DOE environmental remediation studies, such as those of the Natural and Accelerated Bioremediation Research Program and the Environmental Management Science Program. This initiative will draw on the new Joint Argonne-University of Chicago Center for Environmental Science, a formal collaboration that will perform research on environmental issues. Other potential federal sponsors are the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the National Science Foundation (in collaboration with university partners), and the Department of Defense. Required resources are summarized in Table IV.5.

Table IV.5 Grand Challenges in Environmental Science (\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	-	2.0	3.6	5.6	8.0	10.0	10.0
Capital Equipment	-	-	1.0	2.0	2.0	2.0	2.0
Construction	-	-	-	-	-	-	-
Total	-	2.0	4.6	7.6	10.0	12.0	12.0
Direct Personnel	-	5.0	9.0	14.0	20.0	25.0	25.0

Initiative: Synchrotron Environmental Science

Environmental research is undergoing a technical revolution. Environmental scientists, who have long used the classical macroscale research methods of biology, chemistry, geology, and physics, are just beginning to apply the newer microscale research technologies in truly interdisciplinary studies. In the offing are immense benefits from applying recent advances in x-ray spectroscopy, scattering, and imaging. Benefits range widely, including determinations of chemical speciation and mineral-fluid interface structure in the environment, optimization of chemical sequestration technologies, characterization of soil organic matter, insight into carbon sequestration mechanisms, and improved understanding of biotic processes in extreme environmental conditions.

Demand for environmental research capability at the APS is growing rapidly. For example, the

existing GSECARS user program receives many more environmental research proposals than it can accommodate with available beam time. The first Synchrotron Environmental Science workshop, held at Argonne in April 1999, strongly confirmed the growing shortage of beam time relative to worthy research proposals, despite the fact that the National Science Foundation and DOE-BES have already invested heavily in GSECARS and BESSRC beamlines that serve geoscience and environmental science. The second workshop, held in May 2002, demonstrated continued growth in the field of environmental molecular sciences and underscored the research community's need for additional beam time and optimized instrumentation.

Argonne research groups are already undertaking major projects at the forefront of synchrotron environmental science. These research projects utilize beam time at four APS collaborative access teams (BESSRC-CAT, MR-CAT, SRI-CAT, and GSECARS-CAT), as well as at the National Synchrotron Light Source and the Stanford Synchrotron Radiation Laboratory. Substantially more access to APS beam time will clearly be required for the expanded scientific program envisioned in this initiative. Development of new beamline capabilities will be pursued through partnerships with other organizations having complementary research interests.

To meet the need for additional synchrotron environmental science capabilities, Argonne has formed a partnership with the University of Chicago and the University of Notre Dame to establish a new collaborative access team at the APS that will be devoted to environmental research. This collaborative access team (EnviroCAT) is intended to provide dedicated, state-of-the-art facilities that are optimized for research on a broad range of environmental science problems. EnviroCAT will focus on developing a multifaceted microbeam facility and a microtomography facility using, respectively, insertion device and bending magnet beamlines. The letter of intent submitted to the APS program review board has been approved, and work will begin in FY 2003 to develop initial design criteria. Discussions with potential institutional partners are expected to result in additional formalized research partnerships in FY 2003.

Resources envisioned for development of EnviroCAT are described in Table IV.6. Support will be sought from DOE-BER (KP), DOE-Environmental Management (EW, EX), other federal agencies, and private sources.

Table IV.6 Synchrotron Environmental Science
(\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	0.5	1.0	2.0	2.0	2.0	2.5	2.5
Capital Equipment	-	-	2.5	1.5	0.5	-	-
Construction	-	-	8.5	4.0	4.0	-	-
Total	0.5	1.0	13.0	7.5	6.5	2.5	2.5
Direct Personnel	2.0	2.0	10.0	10.0	10.0	10.0	10.0

j. Science and Engineering Education and University Programs

Situation

Argonne has maintained very active and wide-ranging interactions with the academic community throughout its existence. The activities range from programs that support science education at the high school level to mutually beneficial research partnerships between university faculty and Argonne research staff in virtually all of the Laboratory's scientific and technical areas. These activities are supported by the Laboratory, through work for non-DOE sponsors, and by DOE.

Argonne's science and engineering education programs serve faculty and students at both the university and precollege levels. Core programs at the university level provide opportunities for research participation by outstanding undergraduates and faculty, as well as opportunities for thesis research by graduate students. Argonne has become more active in unique graduate programs involving several strategic areas of interest to DOE. These programs include long-term internships and short-term training in a wide range of the Laboratory's research areas. The quality and value of these programs attract applicants from throughout the country.

As part of its education program, Argonne serves the Department of State as the host institution for U.S. participation in training

programs of the International Atomic Energy Agency (IAEA). The Laboratory develops and conducts courses in peaceful applications of nuclear technology and also provides technical support to the Department of State and the IAEA.

Vision

Argonne will enrich science education in the United States through activities that involve local communities, as well as students and faculty at all levels from throughout the nation. The Laboratory will work closely with DOE and other federal agencies to promote peaceful applications of nuclear technology through collaboration with the IAEA and other international organizations.

Objectives

Argonne's primary near-term objectives in support of science education and training are as follows:

- Continue to attract a large, diverse pool of highly qualified undergraduate students to research participation programs.
- Establish the Laboratory's educational user facility as a valuable and widely used resource providing hands-on laboratory experience for science teachers in the region; enhance classroom activities through use of the Internet.
- Foster student interest in science education and science careers through a variety of outreach efforts, such as the Argonne Information Center.
- Fruitfully integrate graduate students, post-doctoral fellows, and faculty into Laboratory research programs through internships and training activities.
- Provide training programs and technical assistance to a variety of international organizations.

Issues and Strategies

For its university-level programs, Argonne plans special efforts to develop supplementary activities that will broaden the science horizons of

undergraduates and provide training and research opportunities for graduate students. Programs for high school students and teachers will focus primarily on hands-on laboratory work using Argonne facilities and distance learning capabilities dedicated to educational activities. In addition, the Laboratory will continue to develop programs exploiting computer technology to enhance classroom science education. Important workshops and conferences, such as the annual Women in Science conference, will continue. International programs will focus on unique Argonne research and training capabilities.

Maintaining a sound funding base is the most important issue currently facing Argonne's educational programs. Support for participants through the Office of Science has included limited infrastructure support. DOE offices with educational and training needs have been asked to consider the advantages of focusing those activities at Argonne. The Laboratory's research divisions plan to continue their strong support for the core educational programs of research participation and thesis research at the undergraduate, graduate, and faculty levels. Support for the operating costs of programs for precollege teachers in nearby school districts and in the Chicago Public Schools will be sought from the districts themselves, as well as from the state of Illinois, agencies of the federal government, and the private sector. Laboratory overhead will support the minimal infrastructure required to manage and administer these programs.

2. Energy and Environmental Technologies

Argonne research programs serving the two DOE mission areas of energy and environmental quality are so intertwined that this section includes area plans related to both.

a. Advanced Nuclear Technology

Situation

The May 2001 report of the National Energy Policy Development (NEPD) Group chaired by Vice President Cheney summarized its endorsement of nuclear power as follows: "The NEPD Group recommends that the President

support the expansion of nuclear energy in the United States as a major component of our national energy policy.” The NEPD Group further recommended reconsideration of next-generation advanced-fuel-cycle technologies: “In the context of developing advanced nuclear fuel cycles and next generation technologies for nuclear energy, the United States should reexamine its policies to allow for research, development, and deployment of fuel conditioning methods (such as pyroprocessing) that reduce waste streams and enhance proliferation resistance.”

In view of these and other recommendations of the NEPD Group, Argonne plans to accelerate its efforts to advance nuclear technology, in order to ensure that nuclear energy can fulfill its promise as a sustainable, clean, safe, long-term energy source, free of carbon dioxide emissions. To this end, Argonne proposes in Section III.B.1 the major Laboratory initiative Advanced Nuclear Fuel Cycle. At the conclusion of this area plan, the Laboratory also proposes expansion of its existing R&D on nuclear technology, which supports current nuclear technologies, as well as those of the near future and the longer-term future.

For more than a half century, Argonne has been a world leader in the development of nuclear energy. The Laboratory’s staff has extensive expertise in the full range of disciplines associated with nuclear reactor technology, and a full complement of experimental facilities is in place, representing many hundreds of millions of dollars of national assets. Currently, Argonne’s nuclear technology R&D focuses primarily on (1) the Nuclear Energy Research Initiative (NERI), which aims at innovative reactor concepts, nuclear science, and nuclear technology; (2) the Nuclear Energy Plant Optimization (NEPO) program, which addresses critical technology issues associated with existing nuclear power plants; (3) the Advanced Accelerator Applications (AAA) program; (4) the Generation IV program, which aims at a new generation of nuclear energy systems to be deployed by 2030; and (5) operation of the International Nuclear Safety Center, intended to improve the safety of nuclear reactors worldwide through collaborative R&D programs and in-depth safety analysis, with primary attention to Soviet-designed reactors and the countries operating those reactors.

In partnership with the Idaho National Engineering and Environmental Laboratory (INEEL), Argonne serves as lead laboratory for Nuclear Reactor Technology for the DOE Office of Nuclear Energy, Science and Technology (DOE-NE). The primary mission for the lead laboratories during FY 2001-FY 2003 is to lead formulation of a “technology development road map” for the Generation IV nuclear energy systems program, with broad domestic and international participation.

Goals

The goals of Argonne’s nuclear technology program are to develop and demonstrate innovative nuclear reactor systems and associated fuel cycles that will ensure that nuclear energy can fulfill its promise as a sustainable, long-term, emission-free source of energy; to aggressively pursue solutions for the important technical issues associated with the use of nuclear energy, both domestically and internationally; to help DOE identify and implement technology development programs that will increase the contribution of nuclear energy to a sustainable global energy supply; and to maintain a set of technical capabilities in nuclear science and technology — including both expertise and infrastructure — sufficiently broad and deep to address a full range of national needs.

Strategies

Key strategies for Argonne’s nuclear technology programs include the following:

- Undertake the major Laboratory initiative Advanced Nuclear Fuel Cycle, including nuclear system R&D and design studies carried out in concert with the Generation IV program and the demonstration of an advanced fuel cycle. (See Section III.B.1.)
- Continue to participate in the NERI, NEPO, and Generation IV programs; apply Argonne’s nuclear expertise and unique facilities to current, near-term, and longer-term future nuclear technologies; and apply Laboratory expertise to critical issues affecting the continued safe and efficient operation of existing nuclear power plants.

- In partnership with INEEL, serve as lead laboratory for reactor technology for DOE-NE.
- Within Argonne's areas of special expertise, participate in advanced technology R&D programs such as the AAA program.

Argonne plans a number of important new directions for its work in nuclear R&D that will support the above strategies:

- *Transient Testing at TREAT.* Argonne has begun work to reactivate the Transient Reactor Test Facility (TREAT) in order to carry out various experiments requiring a reactor capable of producing controlled transients. Though TREAT can be restarted within existing budgets, potential future testing missions will require additional resources. These missions might include testing the safety of fuel containing recycled actinides, testing the safety of advanced fuel concepts that might arise from the Generation IV program, or testing current or new fuel designs for commercial light-water reactors.
- *Advanced Fuels Development.* Argonne proposes to develop advanced fuels for power reactors, research reactors, and test reactors. Programs such as NERI and Generation IV have fostered discussion of various system configurations, but a common feature is a new fuel design. Of particular interest are metal and metal matrix dispersion fuels. Guided by system studies and technology road maps, Argonne will pursue these fuel development options and others.
- *Materials Development for Nuclear Power.* Materials R&D is important for supporting the current fleet of operating nuclear power plants, as well as for developing future innovative nuclear systems. Future nuclear power plants are likely to operate at higher temperatures and have unique corrosion environments, so advanced structural materials will be necessary. Argonne will undertake both fundamental and applied work to (1) investigate improvements in the performance and production of materials potentially

applicable to nuclear power, (2) establish the capability to use modern production and analytical techniques, (3) screen new materials for likely performance in a nuclear environment, and (4) perform prototypic testing of promising advanced materials. Research aimed at both near-term and longer-term applications is proposed.

- *Post-Operation Evaluation of EBR-II Materials and Components.* A complete knowledge of the condition of Experimental Breeder Reactor-II (EBR-II) materials and components will facilitate future reactor decommissioning, life extension for current reactors, and the design of advanced reactors. In order that these valuable data are not lost, Argonne proposes significantly expanded examination of EBR-II materials and components.
- *Severe-Accident Management Technology.* Severe-accident research addresses the question of what could be done at a nuclear power plant if a core melt accident were to occur. The Laboratory's facilities for conducting severe-accident experiments have been designated an international reactor safety R&D facility by the Organization for Economic Cooperation and Development (OECD). A new research program investigating interactions between concrete and a molten reactor core is now under way. Argonne seeks continued funding for this program, whose costs are shared with international partners under OECD auspices. (See Section S1.E.5.)
- *Advanced Modeling and Simulation for Nuclear Applications.* Argonne proposes expanded work in advanced modeling and simulation for nuclear technologies. The first part of this work focuses on developing and implementing numerical methods on state-of-the-art parallel computers and workstation clusters, so that today's computing technology can be applied to improving nuclear reactor analysis. The second part focuses on machine reasoning, automated pattern recognition, and system modeling based on learned input-output relationships.

b. Energy and Industrial Technologies

Situation

Argonne develops innovative, efficient, cost-effective nonnuclear energy technologies and industrial technologies. Emphasis is on advanced transportation (discussed separately in Section IV.A.2.c), “industries of the future” identified by DOE, superconductivity, and fossil fuels and carbon management. The program also coordinates the Laboratory’s development of partnerships with private companies in these areas.

“Industries of the Future.” Process industries convert raw materials into ingredients useful for fabrication and assembly in the automotive, electronics, aerospace, construction, and similar industries. The process industries account for approximately a third of U.S. energy consumption, at an energy cost of about \$100 billion each year. Six of the major process industries — chemicals, forest products, glass, ceramics, metals, and petroleum refining — account for 78% of all industrial energy use, generate 95% of manufacturing waste, cause 95% of the total air pollution attributable to manufacturing, and account for more than 30% of U.S. carbon dioxide emissions. Because they use so much energy and produce so much waste, the federal government has set goals for U.S. process industries for the year 2010 in terms of energy reduction, oil displacement, cost savings, and pollution reduction.

Superconductivity. The electric power industry today faces a wide range of major challenges, including deregulation, aging infrastructure, global warming policies, and dependence on imported oil. Power wheeling across long distances puts a premium on technologies for the transmission and distribution of electric energy that are efficient and robust, and greater interconnectedness necessitates better technologies to protect against overloads and fault currents. Renewable energy sources are increasingly attractive, but solar or wind energy is intermittent and requires energy storage. High-temperature superconductivity technologies are being pursued by DOE and increasing numbers of electric power utilities and their suppliers as a promising response to many of these challenges.

Fossil Fuels and Carbon Management. A prudent carbon management strategy for the utility, industrial, and transportation sectors could significantly decrease net emissions of carbon dioxide and other greenhouse gases. An early, economical opportunity for greater sequestration may be provided by the capture of carbon dioxide at large point sources such as power plants, followed by use for enhanced oil recovery and production of methane from coal beds. Sectors of the economy that consume large quantities of fossil fuels are already adopting more energy-efficient technologies. Strategies for the economical use of less carbon-intensive fuels in existing plants and fleets may be an important bridge to more advanced technologies. However, a full assessment of policy options will require better understanding of carbon transformations “from cradle to grave,” throughout current and proposed energy cycles. Argonne initiatives support DOE strategies to improve the efficiency of fossil energy technologies and to assist the utility, industrial, and transportation sectors in reducing greenhouse gas emission rates in other ways as well.

Partnering. Responding to the administration goal of improving the productivity of U.S. industry through appropriate use of national technical resources, Argonne is developing a broad range of partnerships with industrial firms on the basis of the Laboratory’s leadership in many areas of science and technology. Argonne’s midwestern location in the nation’s industrial heartland provides exceptional regional opportunities. Partnerships with industry play an important role in shaping many Argonne R&D programs.

Vision

Argonne will develop new technologies that increase the productivity of U.S. industry and decrease its environmental impacts, particularly through increases in energy efficiency and reductions in intensity of petroleum consumption. As an integral part of pursuing its mission in science and technology, the Laboratory will continue to develop effective relationships with industry to maximize the commercial applications and benefits to the nation from its R&D.

Goals and Objectives

To implement this vision, Argonne's goals include the following:

- Exploit and expand Argonne facilities, capabilities, and core competencies, which integrate science and technology and interest both the scientific and industrial communities.
- Establish strategic partnerships with key industrial firms, large and small, in areas where applying the Laboratory's technical strengths is most likely to lead to valuable commercial successes.
- Implement effective regional outreach, capitalizing on the Laboratory's midwestern location.

Many U.S. industries are working with the federal government to ensure that federally sponsored R&D provides maximum benefits to the nation. Argonne has established the important research objectives summarized below, which are being pursued in close partnership with industry.

Industries of the Future

- Expand Argonne research benefiting the chemical industry, particularly research in the areas of recovery and reuse of polymers, development of chemicals from alternative feedstocks, catalysis, and plasma-chemical engineering.
- Further develop advanced technologies that improve petroleum refining by developing advanced computational modeling for fluid catalytic cracking to improve overall yields.
- Working with an industrial equipment supplier and a paper industry manufacturer, develop the multiport dryer technique, already demonstrated through proof of concept, into a prototype demonstration unit.
- Maintain the momentum of current research on metals recycling; expand work on instrumentation, materials, and fabrication technologies for the steel, aluminum, glass, and metal casting industries.
- Target key technical hurdles where unique Argonne capabilities and facilities can be used to advantage; for example, use the APS and

the IPNS for critical materials studies that will enable the development of inert metal anodes for aluminum smelting.

- Advance the development of nearly frictionless, nontoxic carbon coatings for moving parts (such as oilless bearings, spacecraft mechanisms, rolling and sliding gear systems, and bearings for ultrahigh-vacuum instruments like x-ray tubes), while contributing more broadly to tribology.
- Expand Argonne research benefiting the glass industry by means of multiphase computational fluid dynamics modeling of glass furnaces; develop new techniques for recycling glass with minimal effect on product quality.

Superconductivity

- Maintain core work on the development of superconductors that is sufficiently large to sustain rapid technical development and foster extensive interactions with industrial companies and universities.
- Continue Argonne's contributions to the development of the second generation of high-temperature superconductors, building on earlier successes with powder-in-tube technology.
- Work with the manufacturers of high-temperature superconducting wire (such as American Superconductor Corporation and Intermagnetics General Corporation) to help advance manufacturing processes.
- Collaborate with system manufacturers (such as Boeing, Southwire, and S&C Electric Company) to develop and demonstrate energy-efficient products for the electric power industry, such as flywheels for energy storage, fault current limiters, electric motors, and transmission cables.
- Collaborate with other national laboratories and industrial partners to develop textured buffer layers — such as MgO, YSZ, Y₂O₃, and CeO₂ — for yttrium-based superconductor films.

Fossil Fuels and Carbon Management

- Expand and help coordinate the development of technologies that are cost-effective and highly efficient, emit smaller net amounts of greenhouse gases, and reduce environmental impacts in the utility, industrial, and transportation sectors; establish emissions inventories for promising technologies and form industrial partnerships to pursue technology development.
- Advance petroleum refining technology by developing (1) catalysts for upgrading heavy crudes, residuum, and distillates and (2) catalytic processing to produce ultraclean low-sulfur transportation fuels through heteroatom removal.
- Investigate opportunities for sequestering carbon dioxide derived from advanced fossil fuel energy systems and from retrofitting technology to the large number of existing long-lived electric generation plants.
- Improve understanding of terrestrial and oceanic responses to natural and anthropogenic changes in atmospheric concentrations of greenhouse gases.
- Develop a center for research on biogeochemical cycling of elements.
- Expand R&D on noncarbonaceous hydrogen production.
- Extend Laboratory breakthroughs in ceramic membrane technologies to advance the development of economical processes for separating oxygen from air and hydrogen from mixed gases (which are critical technologies in the use of remote natural gas and in the efficient refinery production of clean transportation fuels, respectively).

Issues and Strategies

Industry. Through the auspices of the DOE Office of Industrial Technologies, Argonne is working closely with the following industry associations to apply the Laboratory's skills, facilities, and core capabilities:

- Chemicals: Council for Chemical Research
- Refining: American Petroleum Institute

- Forest products: American Forest and Paper Association
- Steel: American Iron and Steel Institute
- Aluminum: Aluminum Association, SECAT LLC
- Metal casting: Cast Metal Coalition
- Glass: Glass Manufacturers Industry Council

In other work, an Argonne initiative aims to develop less costly biotechnological methods of producing valuable products from agricultural materials. See the discussion of Biobased Products in Section IV.A.2.f.

Superconductivity. There is increasing conviction among electric utilities and their suppliers that new technology based on high-temperature superconductivity will provide substantial benefits. This industry support is reflected in projected increases in DOE funding of R&D in the area. Several respected international studies have predicted that global annual sales for all technologies based on high-temperature superconductivity will reach billions of dollars by the year 2020. International competition for these sales will be strong, particularly from Japan and Western Europe.

Argonne is uniquely positioned to develop new technologies based on high-temperature superconductivity. The Laboratory's program of basic science in the field is one of the strongest in the world. Close cooperation continues with the Laboratory's applied superconductivity program, which has produced many notable achievements. Argonne plans to be a major contributor to the development of the second-generation conductor, building on industrial successes already achieved with first-generation powder-in-tube technology. The Laboratory also is contributing to the development of a flywheel incorporating superconducting bearings. Argonne will expand the range of utility applications on which it works, taking advantage particularly of new ideas for fault-current limiters, transmission cables, and motors based on superconductivity. Work in nonutility applications will expand as well, on the basis of innovative ideas in areas such as magnetic separation.

Fossil Fuels and Carbon Management. Among Congress and the presidential administration, there appears to be growing bipartisan support for DOE research related to carbon management. A consortium of major petroleum companies is working with the DOE Office of Fossil Energy to plan major field demonstrations of technologies for the economical sequestration of carbon dioxide. The President's FY 2003 budget request includes additional funding for field-scale testing.

Partnering. Congressional appropriations have continued to reduce funding explicitly available for participation by DOE in industrial partnerships. Argonne's industrial partnerships have been severely constrained by this lack of support.

To maximize the likelihood of establishing effective industrial partnerships in the most promising area of technology, Argonne is seeking opportunities to include other national laboratories and universities in productive strategic collaborations based on the Laboratory's scientific and technical capabilities and its core competencies. The Laboratory has already established a vigorous regional outreach program whose broad goal is to help manufacturers in the Midwest. The Laboratory measures the success of its industrial partnerships by considering the significance and impact of the work accomplished and of the ultimate successful commercialization of new technologies.

c. Transportation Technologies

Situation

The world's transportation system depends critically on petroleum. Oil-derived fuels supply 96% of the energy used to move people and goods. Demand for these fuels continues to grow rapidly, rising by 75% in the United States since the oil crises of the 1970s. Worldwide, the demand for transportation fuels is expected to increase dramatically, especially as developing economies grow. As a result, the world is rapidly approaching the time when a permanent decline in oil production from conventional sources will begin. The Energy Information Administration forecasts that conventional oil production could

begin to decline between 2010 and 2040. As the relative price of transportation fuels rises, vehicles with greater energy efficiency will become increasingly important.

The DOE leads two major research programs designed to reduce oil demand by developing vehicles with greater energy efficiency. These programs are the FreedomCAR Partnership (for light-duty vehicles) and the 21st Century Truck Program (for heavy-duty vehicles). Successful development of vehicles that are dramatically more efficient, along with development of alternative fuels, would reduce oil imports, increase energy security, and reduce environmental impacts.

Argonne's Transportation Technology R&D Center is one of DOE's leading research facilities dedicated to addressing the nation's transportation energy problems. Located in the heart of the Midwest, near the nation's manufacturers of automobiles, trucks, and locomotives, the Laboratory works closely with both manufacturers and suppliers to develop cost-effective technologies that improve fuel efficiency and reduce environmental impacts. Argonne maintains a web site that describes the research facilities and capabilities of its Transportation Technologies program (URL: www.transportation.anl.gov).

Vision

Transportation and energy infrastructure will always be critical to U.S. national security. Argonne's Transportation Technology R&D Center will become the premiere provider of needed knowledge about transportation technology and its application, for the nation's industrial, academic, and government research communities.

Goals and Objectives

Argonne's Transportation Technology R&D Center will support the nation's needs for R&D on transportation technology. This goal will be accomplished through basic research, through technology development, and through the creation of partnerships with industry, academia, and other federal or national laboratories that promote energy self-sufficiency and improve energy- and

transportation-related technologies serving the national interest.

Specific objectives include the following:

- Work with the FreedomCAR Partnership (which includes the DOE Office of Advanced Automotive Technologies, Ford, General Motors, and DaimlerChrysler) to
 - Ensure reliable systems for future fuel cell powertrains, with costs comparable to those of conventional systems (internal combustion engine with automatic transmission) and
 - Enable the transition to a hydrogen economy, ensure widespread availability of hydrogen fuels, and retain the functional characteristics of current vehicles.
- Work with DOE and truck engine manufacturers to improve the efficiency and reduce the emissions of advanced diesel technology for use in vehicles of all sizes.
- Develop new technology with a private-sector partner, General Motors Electro-Motive Division, to meet federal locomotive emissions requirements and still achieve high efficiency.
- Work with DOE to develop advanced off-highway and railroad technologies, on the basis of opportunities identified in consultation with industry stakeholders.

Issues and Strategies

Argonne's transportation research, domestic and international, focuses on the following areas where the Laboratory has organized expertise and unique facilities:

- *Vehicle Systems.* New vehicle systems promise to overcome the main limitations of conventional electric vehicles, namely range and recharging rate. Hybrid vehicles typically employ a small combustion engine with a battery or ultracapacitor. The result is the performance of a conventional vehicle but greater efficiency and fewer emissions. Argonne's Advanced Powertrain Test Facility validates DOE-funded components with data on performance and emissions. The

Laboratory's vehicle systems models can then simulate actual vehicle systems performance and emissions.

- *Fuel Cells.* Fuel cells convert chemical energy directly into electrical energy, cleanly and efficiently. Fuel-cell-powered vehicles could nearly double the energy efficiency of today's conventional vehicles and reduce emissions by 99%. Argonne has developed a partial-oxidation reformer that converts gasoline to hydrogen-rich gas for use in fuel cells based on polymer electrolyte membranes. The Laboratory's Fuel Cell Test Facility is capable of testing fuel cells up to 50 kW in size. Argonne is also developing solid oxide fuel cells for transportation use.
- *Energy Storage Devices.* In response to stringent environmental regulations, Argonne is developing advanced batteries for electric vehicles. In particular, the Laboratory is working through the U.S. Advanced Battery Consortium to develop commercially viable high-power lithium-ion storage batteries. This work ranges from research on materials for improved anodes and cathodes to development of novel low-cost packaging. Argonne's Analysis and Diagnostics Laboratory performs independent evaluations of batteries developed worldwide.
- *Emissions Control.* By focusing on fuel injector systems and sensors, Argonne plans to develop technologies that simultaneously reduce emissions of particulates and nitrogen oxides from gasoline and diesel engines of all sizes. Until recently, the optically dense regions of the fuel spray from injector systems have been very difficult to image. However, insights from using the world's brightest x-rays, provided by the APS, promise improved understanding of combustion and soot formation, leading to the development of more efficient engines.
- *High-Performance Computing.* Argonne has supported the transportation industry in the design and testing of new concepts for aerodynamics, thermal management, and safety features. Two major efforts are analyzing underhood cooling and crash-worthiness.

- *Recycling.* Obsolete motor vehicles contain plastics, chlorofluorocarbons, rubber, glass, and heavy metals that today are generally not recyclable and must be put into a landfill. Working closely with the auto industry, Argonne is developing economical processes for converting vehicle waste streams into recycled products.
- *Advanced Materials.* Argonne's advanced materials program includes the development of nearly frictionless carbon coatings to reduce the friction and wear caused by sliding and rotating vehicle components. The program also includes the development of new technologies for sensors, rapid prototyping, nondestructive evaluation of ceramic parts, compact heat exchangers, and nanofluids for coolants. Each of these materials technologies promises to improve both the performance and fuel efficiency of vehicles. Use of the APS is expected to assist in the development of catalysts and other new transportation materials.

d. Environmental Treatment Technologies

Separate plans are presented for three areas of environmental treatment technologies at Argonne: (1) EBR-II spent fuel pyroprocessing, (2) radioactive and mixed waste treatment, and (3) decontamination and decommissioning (D&D).

i. EBR-II Spent Fuel Pyroprocessing

Situation

For nearly four decades, research, development, and demonstration associated with liquid metal fast breeder reactors were conducted at EBR-II, located about 40 miles west of Idaho Falls, Idaho; the Enrico Fermi Atomic Power Plant (Fermi-1) in Monroe, Michigan; and the Fast Flux Test Facility at the Hanford Site in Richland, Washington. These activities generated approximately 60 metric tons of sodium-bonded spent nuclear fuel. DOE is now responsible for safe management and disposition of this spent fuel.

Sodium-bonded spent nuclear fuel must be treated differently from other spent fuel because of the presence of metallic sodium (a highly reactive material), metallic uranium and plutonium (also potentially reactive), and, in some cases, highly enriched uranium. Metallic sodium in particular presents challenges for the management and ultimate disposal of spent nuclear fuel, because the element reacts with water to produce explosive hydrogen gas, as well as corrosive sodium hydroxide that is likely to be unacceptable for geologic disposal.

Argonne's pyroprocess for treating metallic spent nuclear fuel uses electrorefining, a type of technology often used by industry to produce pure metals from impure feedstocks. Application of Argonne's pyroprocess has been demonstrated for the stainless-steel-clad uranium alloy fuel and blanket assemblies from EBR-II. A modified process could be used to treat oxide, nitride, and carbide sodium-bonded spent nuclear fuel.

Application of pyroprocessing to EBR-II spent fuel involves several steps. The fuel is first chopped, placed in molten salt, and electrorefined. After electrorefining, the molten salt, fission products, sodium, and transuranics (including plutonium) are removed from the electrorefiner, mixed with the ion exchange agent zeolite, and heated so that the salt becomes sorbed into the zeolite structure. Glass powder is then added to the zeolite mixture and consolidated to produce high-level radioactive waste in the form of a ceramic. The uranium from the electrorefiner is removed, melted, and processed in a furnace to produce low-enrichment or depleted uranium ingots. The stainless steel cladding hulls and the insoluble fission products are melted in a casting furnace to produce high-level radioactive waste in a metallic form.

A three-year demonstration of treating EBR-II spent nuclear fuel was completed in 1999. A subcommittee of the National Research Council judged that the demonstration met all success criteria. DOE then selected pyroprocessing (also known as electrometallurgical treatment) for the complete inventory of EBR-II sodium-bonded fuel, work now under way at Argonne-West.

Vision

Through treatment of EBR-II and other sodium-bonded spent fuel, Argonne will demonstrate that pyroprocessing technology is a cost-effective option that provides a viable approach to managing spent nuclear fuel.

Issues and Strategies

In September 2000, Argonne initiated treatment operations with EBR-II fuel. Processing rates will be increased from the demonstration rates to a total of 600 kilograms in the first year. As funding becomes available for additional staffing, the processing goal for the following year will be 2,000 kilograms of heavy metal. The capacity rate of 5 metric tons per year is to be reached after processing improvements are implemented.

An important issue associated with treatment of EBR-II spent fuel is continued development of the pyroprocess treatment technology in order to achieve the throughput rates required for economical operation. Although the basic technology has been demonstrated, product losses and waste streams should be reduced, new equipment should be produced, and batch size should be optimized. The cost of continued technology development will be a significant fraction of total costs during the first several years of operation.

Waste form development and qualification will extend well into the schedule for treating EBR-II spent fuel, because licensing of the new waste forms for ultimate disposal in a repository requires completion of an extensive behavior characterization database, reflecting both short-term tests and long-term tests with actual radioactive wastes that will extend several more years. Nevertheless, tests with surrogate fission products and limited tests with actual radioactive waste forms have provided sufficient data to establish the viability of the new waste forms.

*ii. Radioactive and Mixed Waste Treatment**Situation*

Many of DOE's highest-priority business goals depend directly on the Department's environmental program, specifically on the objectives of the DOE Office of Environmental Management (DOE-EM). Included in the DOE-EM plan is application of new technologies that have reached various stages of development with support from the DOE-EM Office of Science and Technology.

Argonne has demonstrated significant core capabilities in advanced environmental technologies, built on its broad competencies in nuclear technology and environmental science and technology; its existing nuclear facilities; and its extensive understanding of and experience in resolving complex environmental problems at sites of DOE, the Department of Defense, other federal agencies, and U.S. industry. Integration of capabilities in environmental research, technology development and deployment, comprehensive assessment, and remediation applications is the basis for Argonne's continuing development of advanced environmental technologies tailored specifically to particular facilities and waste streams for many different types of customers.

Argonne plans to construct the Remote Treatment Facility (RTF) at Argonne-West to provide the infrastructure needed to carry out three missions important to DOE, the state of Idaho, and the national nuclear complex: (1) near-term management of wastes resulting from nuclear research conducted in earlier years at Argonne-West and INEEL, (2) R&D to achieve nuclear energy and national security goals, and (3) R&D to achieve environmental technology goals. Special needs in each of these three areas require that DOE operate facilities dedicated to the development, testing, and implementation of technologies and processes involving the remote handling of highly radioactive materials and the use of intense radiation sources. Argonne will operate the RTF both to meet local waste management needs and to serve as a national user facility for the development and testing of remote technologies. The RTF will augment the existing Hot Fuel Examination Facility (HFEF) at Argonne-West. Development of the RTF will

include an addition to the present HFEF and integration of existing HFEF support capabilities, such as analytic chemistry laboratories, into RTF operations.

The 1995 settlement agreement and consent order in the action “United States v. Batt” (the Batt Agreement) requires that DOE provide the treatment and preparation needed for all transuranic waste located at INEEL and ship the waste out of the state of Idaho by 2018. To meet near-term commitments specified in the settlement agreement, the RTF must be operational by 2006. During FY 2001, DOE approved the mission need statement for the RTF.

Vision

Argonne will advance understanding of environmental problems and will develop technologies that allow cost-effective remediation or prevention of those problems for nuclear waste, mixed waste, and other contaminants.

Objectives

Argonne’s work on advanced environmental technologies has the following central objectives:

- Develop technologies and facilities for treating mixed waste and nuclear materials.
- Develop superior waste forms and methods of testing and validating techniques for predicting performance.
- Develop innovative environmental technologies that exploit the state of the art in separation science, chemical interactions, and advanced materials.
- Integrate scientific research with field engineering experience and methodologies in order to develop cost-effective solutions to environmental problems.

These Argonne objectives clearly help to address two “gaps” identified in DOE’s September 2000 R&D portfolio analysis for its Environmental Quality mission area: (1) dispose of transuranic, low-level, mixed low-level, and hazardous waste (gap number 8) and (2) manage nuclear material (gap number 6).

Issues and Strategies

Development of advanced technologies for mixed waste treatment is a logical extension of Argonne’s broad background in reactor technology. In mixed waste treatment, Argonne plans to continue to specialize in remote-handling operations, transuranics, waste form development, environmental process monitoring, and non-thermal treatment options.

Argonne-West already deals with significant amounts of remotely handled radioactive and mixed wastes, which are stored at its Radioactive Scrap and Waste Facility. These wastes require additional characterization, segregation, treatment, and repackaging.

The RTF will be designed to segregate, characterize, treat, and repackage remotely handled materials. The essential features of the RTF are an air atmosphere hot cell with 13 work stations, a hot repair area with access to the hot cell, waste cask handling capabilities, and a cell for nondestructive analysis. Equipment to be installed in the RTF includes a liner disassembly station, an automated waste sorting station, a sodium removal station, an induction furnace, and a waste repackaging station. Direct linkage with the HFEF will be through a cask tunnel. The cask transfer system will be capable of dealing with many types of casks, including the commercial nuclear fuel casks that are licensed for remotely handled transuranic waste. Waste packages that are not compatible with casks will enter the RTF cell through the hot repair area.

Development of stabilized waste forms is very important for solving problems associated with high-level and mixed waste. During the last decade, Argonne has performed a wide range of R&D contributing to waste form development, including long-term and accelerated testing of high-level waste glasses and technical support to the Yucca Mountain Project, development of room-temperature setting of chemically bonded phosphate ceramic waste forms, studies of glass compositional envelopes for DOE-EM, definition of performance specifications for Hanford low-level wastes, and phosphate mineralization of actinides achieved by the measured addition of precipitating anions. Argonne will continue to support DOE programs such as the high-level

waste repository and the Waste Isolation Pilot Plant. In addition, technical support will be provided to DOE field offices and to the site contractors at major sites charged with cleanup and waste management, such as Savannah River, Fernald, Rocky Flats, INEEL, and Hanford.

Argonne will continue to support DOE-EM R&D aimed at long-term disposal of waste forms. This research centers around the physics and chemistry of surfaces and interfaces; development of new waste forms for “problem” wastes; and modeling, validation, and performance testing.

iii. D&D

Situation

Decontamination and decommissioning of production and research reactors and nuclear manufacturing facilities represents a major challenge for DOE and the commercial nuclear industry. Problems associated with D&D include safe and effective dismantlement of contaminated and radioactive components; packaging, transportation, and disposal of waste; and recycling and reuse of material.

Argonne is uniquely positioned to assume a leadership role in the development and demonstration of D&D technologies. A number of the technologies already developed or under development at the Laboratory can be applied to D&D, including advanced cutting technologies (such as lasers, water jets, and plasma arcs), effluent control technologies (such as filters for aerosols and dissolved contaminants), instrumentation, decontamination methods (both chemical and mechanical), and risk assessment methods.

Argonne is building its D&D technology program on a strong foundation of extensive experience in nuclear and environmental work, recent success in applying D&D technologies, and valuable strategic partnerships. The Laboratory has experience with the D&D of many types of nuclear facilities, including reactors, hot cells, and facilities containing glove boxes. The most significant of its reactor D&D projects involved the CP-5 Research Reactor and the Experimental Boiling Water Reactor. Argonne also has a long history of developing and deploying both nuclear

and nonnuclear technologies, and it has played a leading role in this country’s first D&D technology demonstration program at a working D&D site. The CP-5 Large Scale Demonstration and Deployment Project was judged one of DOE’s “Top 100 Achievements of the Century.” The Laboratory has been instrumental in developing risk-based analyses for recycle and release criteria and for transportation. Its RESRAD (RESidual RADioactivity) family of computer codes is widely used by regulators to aid in evaluating compliance, through estimation of doses and related risks to human health and the environment that result from exposure to radioactivity and chemically contaminated materials. Argonne has also developed cost-engineering models that have been used to validate cost estimates throughout the DOE complex. Argonne is active in several international organizations involved in D&D and has initiated information exchange programs with the International Atomic Energy Agency, Japan, Russia, and Argentina.

Vision

To optimize the cost-effectiveness and safety of D&D operations, Argonne’s D&D technology program will continue to advance the development, demonstration, and deployment of cost-saving D&D technologies and to develop and execute analyses of risk, safety, environmental impacts, and costs for DOE, other federal agencies, regulators, and the commercial sector. The program will also continue its contributions to D&D education through training, workshops, and personnel exchanges.

Objectives

The main objectives of Argonne’s D&D technology program are the following:

- Provide substantive information on the use and value of D&D technologies for all categories of end users.
- Coordinate the research, development, demonstration, and evaluation of D&D technologies in order to achieve cost-effective D&D for the DOE complex.
- Provide technical services and support in the areas of risk, safety, and cost analysis, as

well as in planning and technology deployment.

- Provide D&D training and participate in informational and educational exchange both domestically and internationally, including support for D&D in the former Soviet Union.
- Work with the DOE Environmental Management Science Program to encourage basic research in areas that will benefit D&D technology.

Issues and Strategies

Key to the development of Argonne's D&D technology program is formation of strategic alliances among national laboratories, utilities, universities, D&D contractors, and technology developers and providers. Argonne will continue to pursue appropriate alliances with nuclear utilities and D&D contractors, as well as with the Nuclear Energy Institute and the Electric Power Research Institute. In all its D&D technology efforts, Argonne is working closely with DOE-Chicago Operations. Internationally, Argonne will take advantage of the Laboratory's strong international research reactor program, which dates back to Argonne's design of research reactors and, more recently, to the design and implementation of proliferation-resistant fuels for research reactors.

A number of external and internal factors will influence the success of Argonne's D&D technology program. External factors include scheduling of D&D by DOE and utilities, effects of utility deregulation, and the availability of low-cost disposal sites for low-level nuclear waste. Internal factors include close integration of the Laboratory's diverse capabilities in technology and advanced technical services. Equally important is the formation of partnerships and strategic alliances with organizations outside the Laboratory.

e. Energy and Environmental Systems

Situation

Long-term energy resources and environmental impacts from energy consumption remain controversial public concerns complicated by

economic importance and contradictory public perceptions. Informed decision making in this area requires accurate, clearly presented analyses based on a very wide range of technical information. Federal policy analysis is further complicated because responsibilities relating to energy and the environment are spread widely across federal agencies. No single agency has a mandate to examine the full range of relevant issues.

For decades, Argonne has created technically and economically efficient solutions for energy and environmental problems by applying scientific methods in the development and assessment of new and modified technologies and processes. The Laboratory's successes in this area stem from its capacity to assemble interdisciplinary teams of specialists and to integrate diverse technical resources in order to address difficult problems through focused study and exploitation of unique facilities. A particular Argonne strength is its capability for merging decision analysis, risk assessment, information sciences, and economic evaluations with the engineering specialties and the physical, biological, and social sciences.

Energy and environmental problems create these challenging national needs:

- The rapidly growing complexity of the energy system and related environmental issues necessitate a multidisciplinary, integrated approach to solutions.
- Solutions to environmental problems must be both cost-effective and acceptable to the public.
- The growing information glut facing all decision makers requires the development of better ways to capture, merge, and display critical information.
- Such policy areas as climate change, pollution remediation, and resource management increasingly require global analysis and international coordination.
- There is growing evidence that restructuring of the U.S. electric system requires new approaches to reliability, environmental protection, and preparation for disruptions. At the same time, new environmental regulations require the development and adoption of advanced procedures and technologies.

- The benefits of increasing the production of fossil fuels on U.S. public lands must be balanced against the need to protect environmental quality.

Vision

Argonne will provide national and international leadership in the creation of innovative and cost-effective solutions to energy and environmental problems, through the development of next-generation technologies; through the application of state-of-the-art techniques in assessment, risk analysis, and decision analysis; and through the transfer of those technologies to the private sector and other researchers.

Objectives

Key objectives of Argonne's program in Energy and Environmental Systems include the following:

- To improve the analysis and assessment of advanced energy systems, develop models, methodologies, and techniques that give decision makers more accurate information about the changing structure of the energy system, particularly the electric power system.
- Develop integrated environmental assessments, risk analyses, modeling techniques, and innovative information systems (by using approaches such as advanced visualization, advanced data management techniques, and spatial and geographic information systems) that benefit federal managers, policy makers, and private-sector businesses facing new regulatory requirements.
- Apply these energy and environmental tools, techniques, and methodologies to issues of national concern; transfer the tools to other researchers and to private-sector energy organizations for improved decision making.
- To improve the cleanup and subsequent long-term stewardship of Cold War legacy waste sites, make available more widely — to DOE, federal, and private-sector sites — the benefits of Argonne's unique capabilities in information management; in tools for assessing the changing structure of energy

systems; and in methods of site characterization, remediation, and restoration.

- Expand the Laboratory's international activities that address global climate change and environmental protection.

Issues and Strategies

Argonne's strategies for achieving its objectives in Energy and Environmental Systems include the following:

- Take advantage of Argonne's strengths in high-performance computing and multidisciplinary domains to investigate the application of advanced techniques — such as complex adaptive systems analysis and agent-based simulation — and provide better decision making information in the rapidly changing, highly complex, nonlinear arena of energy and environmental policy.
- Combine innovative decision tools with field techniques to create applied environmental methodologies that are more effective. For example, tailor more cost-effective approaches to site cleanup and long-term stewardship through better site sampling strategies, better monitoring methodologies, and more flexible decision-making practices based on rapid acquisition and evaluation of accurate field data.
- Address emerging technical issues associated with long-term environmental stewardship at DOE and other federal facilities, especially sites requiring extensive cleanup. (See discussion of the initiative Science and Technology for Environmental Stewardship at the end of this area plan.)
- Collaborate with urban community groups to increase the stock of energy-efficient buildings, including housing and schools; to return abandoned sites to use; and to design and implement next-generation modes of urban transportation. These efforts will include integration of Argonne techniques, technologies, tools, and training to foster the creation of more high-wage jobs, to ease urban blight, and to support the renovation of urban infrastructure.

- Explore additional opportunities to apply the Laboratory's special capabilities beyond DOE, to benefit the Departments of Defense, Agriculture, and the Interior; the Nuclear Regulatory Commission; other federal agencies; state and municipal governments; nongovernmental organizations; and the private sector.
- Expand activities with international organizations and appropriate foreign governmental organizations involving the analysis of international issues concerning energy and environmental systems — including global electric system restructuring, transnational energy system interconnections, global climate change, sustainable development, hazardous waste generation, and ecosystem management.

In summary, Argonne has considerable strength in most scientific and technical areas related to energy and the environment. The Laboratory is well organized to integrate its multidisciplinary capabilities in research, development, and demonstration of new technologies. Recognition of these capabilities has allowed Argonne to develop solutions to a wide variety of real-world problems and to strengthen its relationships with sponsors further. Current challenges include developing innovative methodologies for analyzing energy and environmental problems (such as global climate change and restructuring of the electricity market) that cannot be addressed adequately with conventional techniques; identifying appropriate opportunities for beneficial external collaboration; and extending the breadth and depth of the Laboratory's capabilities.

Initiative: Science and Technology for Environmental Stewardship

The DOE R&D portfolio analysis for the Environmental Quality mission area in September 2000 identified long-term environmental stewardship as one of four highest-priority technical "gap" categories. In response to this need, Argonne proposes a program of research, development, and analysis to address emerging technical issues associated with the environmental

stewardship of lands and facilities for which DOE and other federal agencies are responsible.

The concept of environmental stewardship encompasses the mechanisms — physical and institutional controls, information management, environmental monitoring, risk assessment, and other means — needed to ensure, in both the short term and the long term, protection of people and the environment. Government is responsible for stewardship of the lands it manages and for the environmental consequences of its activities. Planning for effective stewardship includes evaluating impacts from the use of rights-of-way on federal lands (such as the Trans-Alaska Pipeline system); assessing the effects of extracting energy and other resources; and developing effective methods of managing residual contamination left following cleanups at government facilities.

This initiative in Science and Technology for Environmental Stewardship takes advantage of Argonne's substantial capabilities and experience in characterization, in analysis and engineering for processes and systems, and in integrated management, including risk assessment. The initiative will emphasize (1) decision making related to risk to human health and ecosystems and (2) monitoring to obtain feedback for updating previous decisions. Such risk assessment requires integration of results from multiple analyses, models, and monitoring. Associated decision making processes often involve disparate stewards, regulators, and the public. Informed decision making depends critically on effective integration and dissemination of relevant information. To create an improved technical basis for stewardship, the Laboratory will investigate the deployment of technologies and approaches it has developed by using advanced techniques of computing and communications.

Resources that can be applied beneficially to this initiative are described in Table IV.7. Funding will be sought initially from DOE-EM (EW, EX); Environment, Safety, and Health (HC); and Science (KP-12, KP-13).

Table IV.7 Science and Technology for Environmental Stewardship (\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	9.3	9.7	10.0	13.0	15.0	17.0	19.0
Capital Equipment	0.2	0.3	0.4	0.5	0.5	0.5	0.5
Construction	-	-	-	-	-	-	-
Total	9.5	10.0	10.4	13.5	15.5	17.5	19.5
Direct Personnel	28.0	30.0	32.0	39.0	40.0	41.0	42.0

f. Biotechnology

Situation

Biotechnology research at Argonne is a multidisciplinary, cross-cutting activity that integrates a variety of disciplines and unique research facilities. The Laboratory is one of DOE's leading resources for developing the technologies of biological microchips and biobased chemicals. Key elements of the Laboratory's program are sponsored by DOE, the Department of Defense, and private-sector industrial collaborators. Near-term plans include further strengthening of capabilities in biocatalytic and downstream processing, in bioinformatics, and in the development of automated systems for gene cloning and expression.

Objectives

Key objectives of Argonne's biotechnology program include the following:

- Development of biological microchips (biochips) for the detection of mutations in human genes and identification of viruses, bacteria, and bacterial toxins
- Evaluation of biochemicals for control of cellular malignancies
- Development of advanced emergency resuscitation technologies, improved artificial intelligence for medical diagnostics, and new prosthetic materials and coatings
- Development of industrial processes based on environmentally friendly, biologically based chemicals and solvents

- Development of technologies to monitor, remove, detoxify, and recover heavy metals, organic compounds, and bacteria in the environment

Issues and Strategies

In addition to national security, Argonne's programs in biotechnology focus on three promising areas having high national priority:

- *Medical Applications.* Programs emphasize development of advanced biochips for analyzing genetic information, studying cancer and biochemicals to guide pharmaceutical development, and developing advanced devices and procedures for emergency resuscitation.
- *Industrial Processes.* Programs include the development of environmentally friendly "green solvents" and biobased chemical production processes (e.g., the use of corn as feedstock for producing chemicals such as ethyl lactate and succinic acid).
- *Environmental Protection.* Programs include investigation of environmentally acceptable methods for treating microbial corrosion in pipelines; field demonstrations of phytoremediation methods; and development of photocatalysts for the removal, detoxification, and recovery of heavy metals and organic compounds in aqueous waste streams.

Initiative: Biochips and DNA

Argonne's established biochip program is invigorated by the continuing rapid emergence of novel potential applications for biochip technology, particularly applications that involve DNA decoding and imply valuable opportunities for spin-off initiatives. These spin-offs are currently focused on four key areas:

- Analysis of changes (mutations) in genetic makeup
- Identification of bacteria, viruses, and their products
- Detection and rapid analysis of biological threat agents

- Development of phylogenic chips to improve analytic sensitivity

Argonne's Biochips and DNA initiative aims to develop and apply both generic and customized biochips in the above areas. Generic biochips are useful for reading unknown sequences, and customized biochips are used to study phenomena such as gene polymorphism (which may be associated with susceptibility to various autoimmune diseases). A recent thrust is the collaborative development of a three-dimensional biochip that offers major advantages over currently available two-dimensional designs. The resources required for this initiative are summarized in Table IV.8. The funding increase for FY 2003 is sought from DOE, other federal agencies, and the private sector.

Table IV.8 Biochips and DNA
(\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	4.0	4.4	4.4	4.4	4.4	4.4	4.4
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	4.0	4.4	4.4	4.4	4.4	4.4	4.4
Direct Personnel	10.0	11.0	11.0	11.0	11.0	11.0	11.0

Initiative: Biobased Products

Argonne's biobased products program, like the Laboratory's biochip technology program, is an established activity that often spins off initiatives as novel potential applications are identified. Current components of the Biobased Products initiative range from the development of additional uses for corn as a chemical feedstock to the development of advanced membrane processes that lower the cost of downstream processing and purification. Nanoscience and structural biology are being applied to address fundamental issues in biocatalysis and processing, particularly issues that affect product cost. Resources required for this initiative are summarized in Table IV.9. Funding is sought from DOE-Energy Efficiency (ED), DOE-Fossil Energy (AA), other federal agencies, and industrial partners.

Table IV.9 Biobased Products
(\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	2.5	2.5	3.0	3.0	3.0	3.0	3.0
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	2.5	2.5	3.0	3.0	3.0	3.0	3.0
Direct Personnel	10.0	10.0	12.0	12.0	12.0	12.0	12.0

3. National Security

As stated by Secretary Abraham, national security is the overarching mission of DOE. It is also one of the four traditional underlying mission areas of the Department.

a. Nuclear Nonproliferation and Arms Control

Situation

Argonne's current nonproliferation work aims to reduce the threat to U.S. national security posed by nuclear, chemical, and biological weapons. At the end of the Cold War, the principal threat to U.S. national security changed from large-scale nuclear war to asymmetric conflicts and terrorist activities by subnational groups. The Laboratory's earlier focus on technical means to verify treaty compliance has shifted toward developing ways to limit the spread of weapons of mass destruction.

Among the most pressing problems facing the United States is the breakdown of systems for controlling nuclear materials in Russia and the independent states that resulted from the dissolution of the former Soviet Union (FSU). The United States is one of several countries providing technical assistance to these nations to help improve their systems for control of nuclear materials.

Argonne's nonproliferation and arms control program, with an annual budget totaling approximately \$20 million, includes several significant components:

- The Reduced Enrichment for Research and Test Reactors (RERTR) program, which

develops new fuels, targets, and analysis methods to enable research reactors throughout the world to replace highly enriched uranium in their fuel and targets with low-enrichment uranium.

- The Material Protection Control and Accounting (MPC&A) program, which assists nuclear facilities in Russia and the countries of the FSU. Assistance is offered through surveying the current status of protection and accounting for nuclear materials, making recommendations for improvements, and coordinating upgrade plans and their implementation. This program includes training courses offered both at Argonne and abroad, to enable foreign specialists to effectively utilize new security and accounting systems.
- The Verification Technology program, which develops sensitive and selective instruments to detect radiation and chemical and biological effluents that might indicate clandestine proliferation.
- The Nuclear Export Control program, which provides technical assistance to the National Nuclear Security Administration (NNSA). The assistance includes (1) assessments of proliferation risk associated with proposed exports of nuclear and nuclear-related dual-use material, equipment, and technologies and (2) establishment and improvement of effective systems of export control in Russia and countries of the FSU.
- Packaging and storage of nuclear materials from the BN-350 breeder reactor in Kazakhstan, which implements U.S. non-proliferation goals by improving the security of the plutonium in the BN-350 spent fuel and blanket assemblies.
- Irreversible shutdown of the BN-350 breeder reactor in Kazakhstan, which serves U.S. nonproliferation goals by ensuring that the reactor can never again produce nuclear materials suitable for weapons. This program utilizes a unique organizational approach in which integrated design teams are established between various Kazakhstan organizations and Argonne to resolve issues that arise.

- The joint U.S.-Russian materials disposition program, which targets the disposal of excess weapons plutonium by reactor irradiation. As part of this effort, the BN-600 fast reactor is being converted to a configuration that burns plutonium.
- The Highly Enriched Uranium Transparency Program, which monitors the blending down of highly enriched uranium from dismantled Russian nuclear weapons to produce low-enrichment uranium for eventual use as commercial reactor fuel in the United States, thereby encouraging compliance with international treaty obligations and reducing the threat of nuclear proliferation.
- The Initiatives for Proliferation Prevention (IPP) and the Nuclear Cities Initiative (NCI), which engage former nuclear, biological, and chemical weapons workers in Russia, Ukraine, and Kazakhstan in development of new civilian, peaceful occupations, in collaboration with U.S. companies working under cooperative R&D agreements with Argonne scientists. (The NCI only helps workers in Russian closed cities.)

Mission

By exploiting the technical and analytical expertise of Laboratory staff and the Laboratory's facilities for physical and biological research, Argonne supports the efforts of federal agencies to reduce threats to national security that would result from the proliferation or use of weapons of mass destruction. In addition, Argonne helps to implement associated U.S. policy initiatives.

Issues and Strategies

Argonne plans to integrate and increase its support for nuclear nonproliferation initiatives, particularly by exploiting the Laboratory's unique expertise in nuclear and sensor technologies. The RERTR activities will involve extensive cooperation with Russia and more than 25 other countries. Many international research reactors are today fueled with highly enriched uranium and cannot be converted to low-enrichment fuel by using current technologies. The Laboratory plans to develop the required new nuclear fuels. In

addition, the Laboratory will develop new targets and chemical processing to produce molybdenum-99, an important medical radioisotope, by using low-enrichment uranium instead of highly enriched uranium. The Laboratory also plans to develop new instruments to detect the presence of chemical and biological weapons. Argonne expertise will be used to enhance the security of nuclear materials at additional sites in the FSU and also to reduce the availability of weapons-usable materials by reducing stockpiles of highly enriched uranium. Other activities will focus on developing spin-off projects related to the Laboratory's established MPC&A and training programs in Russia and the countries of the FSU. Laboratory technical staff will continue to support NNSA efforts to promote effective nuclear export controls. The IPP program will be extended to engage former biological and chemical weapon workers in the FSU. The NCI program will help place former nuclear weapon scientists in commercial projects at the Sarov Open Computing Center. On the basis of its expertise in nuclear fuel management, the Laboratory has a technical leadership role in packaging and storing spent nuclear fuel at the BN-350 fast reactor in Kazakhstan to improve the material's proliferation resistance. In addition, Argonne was selected to serve as one of two lead laboratories for a proposed project to assist Russia with the design and construction of a dry storage facility for fuel awaiting reprocessing at Mayak. The initiative Nonproliferation Technologies, discussed below, proposes significant expansion of Argonne's work on the development, demonstration, and deployment of nuclear material safeguard technologies.

Recent terrorist attacks have underlined the need for increased attention to national nuclear security and homeland defense. Weapons of mass destruction and the materials that are key to their production must continue to receive attention, and the need to address nontraditional challenges has risen to unprecedented importance. Systems originally designed to address more traditional threats must evolve in order to plan adequately for and respond to new potential targets, different modes of delivery, different weapons, and different consequences, including functional defeat of critical economic infrastructure and

processes. To strengthen the prevention of domestic and international nuclear events, Argonne proposes five new initiatives:

1. Nonproliferation Technologies
2. Nuclear Fuel Cycle Technology Applications
3. Training for Specialists in Nuclear Material Protection and Law Enforcement
4. International Nuclear Safety and Cooperation
5. Integrated Research Reactor Safety Enhancement Program

Initiative: Nonproliferation Technologies

Argonne proposes significant expansion of its activities related to the development, demonstration, and deployment of nuclear material safeguard and process monitoring technology. For NNSA and DOE-EM, the Laboratory's established sponsors in these areas, this initiative addresses nondestructive assay of materials, monitoring and surveillance systems, and advanced software products. The Laboratory will also leverage its expertise in special nuclear material handling and physics, along with its associated facilities and materials, to conduct process testing of related technologies developed at Argonne and elsewhere in the DOE complex. Technology development initiatives will be tied to the Laboratory's unique physical resources — including its nuclear materials and remote handling facilities — and ongoing nuclear technology projects. These broadly applicable technologies could also serve DOE-Civilian Radioactive Waste Management and the Department of Defense, as well as other federal agencies.

This Nonproliferation Technologies initiative obtains strong leverage from core Argonne programs in spent nuclear fuel treatment, nuclear waste, nonproliferation, facility operations, nuclear safety modeling, and other areas.

Funding for this initiative will be sought from NNSA (NN), DOE-EM (EW); and the Department of Defense. See Table IV.10.

Table IV.10 Nonproliferation Technologies
(\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	1.0	2.5	3.5	3.5	3.5	3.5	3.5
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	1.0	2.5	3.5	3.5	3.5	3.5	3.5
Direct Personnel	2.5	5.0	7.5	7.5	7.5	7.5	7.5

***Initiative: Nuclear Fuel Cycle
Technology Applications***

Argonne is a leader in the technology of the nuclear fuel cycle. This initiative proposes application of Laboratory expertise and facilities to reducing the likelihood of diversion of nuclear materials throughout the nuclear fuel cycle, to identifying materials detected in illicit commerce, and to characterizing materials that might be encountered in a nuclear incident.

***Methodology for Nuclear Fuel Cycle
Observability and Transparency***

Observability and transparency are critical objectives in improving the proliferation resistance of existing and future nuclear fuel cycles. Advanced nuclear fuel cycles must be designed to maximize those attributes for the facilities of all nonweapons member states of the IAEA. Initially designing fuel cycle processes and operations to be more observable and transparent reduces the potential for undetected proliferation. A formal methodology for implementing observability and transparency facilitates integration of attributes inherent in plant operation with advanced information and unattended-monitoring technologies. Such integration will achieve the goal of timely verification that only declared operations are being conducted within declared facilities. Such an advanced methodology combines positive verification (i.e., material accountancy) with negative verification (i.e., operations accountancy) to increase the effectiveness of safeguards.

Nuclear Material Attribution

The ability to determine (1) where nuclear materials originated, (2) the capabilities by which they were produced, and (3) the ways in which they might be used is important for interdicting illicit commerce in nuclear materials and for determining the source of nuclear materials obtained by terrorists. Argonne proposes to apply its expertise in nuclear fuel cycles to these three tasks as an expansion of its current work on materials attribution for homeland defense.

Nuclear Material Characterization

Emergency response and mitigation in response to a terrorist attack involving a radiological dispersion device or a crude nuclear device require knowledge of the character of the materials involved and the phenomenology of the device. Argonne proposes to apply its expertise to planning for the characterization of materials produced from such a device (e.g., by understanding the materials' signatures), identifying possible pathways to communities and the environment, and developing means of mitigating the impacts.

Resources for this initiative will be sought from DOE-Defense Nuclear Nonproliferation (NN), the Department of Defense, and other agencies involved in homeland defense. See Table IV.11.

Table IV.11 Nuclear Fuel Cycle Technology Applications (\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	1.2	2.0	2.5	2.5	2.5	2.5	2.5
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	1.2	2.0	2.5	2.5	2.5	2.5	2.5
Direct Personnel	5.0	9.0	11.5	11.5	11.5	11.5	11.5

***Initiative: Training for Specialists in
Nuclear Material Protection and Law
Enforcement***

For several years Argonne has supported the MPC&A program of NNSA by providing training

to nuclear security personnel from Russia and the countries of the FSU. This training, conducted at the MPC&A Training Facility at Argonne-West, teaches the latest security concepts and gives students hands-on experience in operating electronic and computerized security systems. In coming years, Argonne will offer to expand the number of classes conducted and thereby enable NNSA to accelerate completion of its MPC&A projects. In addition, the Laboratory will offer its security training facility and expertise to help law enforcement officials meet their homeland security responsibilities. The Laboratory is currently discussing with local law enforcement officials their training needs related to access control for courts, public buildings, and airports.

In addition to offering security experts for foreign projects, Argonne stands ready to provide experts for surveys in support of homeland security.

Resources required are summarized in Table IV.12. Funding will be sought from DOE-Defense Nuclear Nonproliferation (NN).

Table IV.12 Training for Specialists in Nuclear Material Protection and Law Enforcement
(\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	2.0	2.5	3.0	3.5	3.5	3.5	3.5
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	2.0	2.5	3.0	3.5	3.5	3.5	3.5
Direct Personnel	4.0	5.0	6.0	6.5	6.5	6.5	6.5

Initiative: International Nuclear Safety and Cooperation

Argonne's ongoing Soviet-Designed Reactor Safety Program, which assesses the safety of Soviet-designed power reactors, has demonstrated the need for continued U.S. engagement with less developed countries seeking peaceful use of nuclear technologies. Moreover, the ongoing program has revealed important nuclear safety and security issues that extend beyond power reactors.

Therefore, the Laboratory proposes to expand its current program to collaborate with countries wishing to assess and address such issues throughout the life cycle of nuclear material. The focus of the expanded program will be assessments of the greatest risks facing nuclear fuel production, transportation, power production, and waste handling activities within a country. Risks considered would include both internal and external threats, whether accidental or intentional, and assessments would recognize the unique circumstances of particular facilities, such as their locations with respect to population centers and the adequacy of local infrastructures to monitor and control nuclear operations. Building on Argonne's safety assessment experience in the FSU, the expanded program would make risk-based recommendations to the countries assessed and to the NNSA about ways to minimize the vulnerabilities of facilities. The new program would include collaborative training, coordinated between Argonne and the IAEA, to transfer safety assessment technology to the participating countries and to link those countries into the network of international nuclear safety centers to improve communication on nuclear safety.

The International Nuclear Safety and Cooperation program will complement the Integrated Research Reactor Safety Enhancement Program (IRRSEP) proposed below, which will specifically address safety and security issues facing research reactors throughout the world. Countries wanting to improve the safety of their research reactors would also benefit from a comprehensive, integrated assessment of other nuclear risks that they face. Such countries could, for example, be encouraged to shut down outdated research reactors if the United States offered training in health physics or emergency preparedness that helped them manage other nuclear operations.

Resource requirements are given in Table IV.13. NNSA funding (AF-15-30) would be supplemented by funding from the U.S. Agency for International Development and from the Nonproliferation and Disarmament Fund.

Table IV.13 International Nuclear Safety and Cooperation (\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	0.6	3.0	5.0	4.0	3.0	3.0	3.0
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	0.6	3.0	5.0	4.0	3.0	3.0	3.0
Direct Personnel	2.0	6.0	7.0	6.0	5.0	5.0	5.0

Initiative: Integrated Research Reactor Safety Enhancement Program

Argonne proposes to significantly expand its work in the area of cooperation and safety enhancement for international research reactors. Research reactors represent a unique safety and security risk for less developed countries. An integrated approach to addressing these risks — based on Argonne’s experience in work with research reactors, international safety networks, fuels, and decommissioning — can offer NNSA a more powerful way to improve research reactor safety. By leveraging existing safety infrastructures, the Laboratory can approach facilities of concern in a cooperative manner, assess vulnerabilities, and provide substantial assistance in the areas of fuel characterization, stabilization, and disposition; safety and security upgrades; safety infrastructure development; and emergency response preparedness.

Argonne has a long history of working with the owners and operators of foreign reactors and their support organizations to assess and improve nuclear safety. Establishment of networked international nuclear safety centers will continue to provide valuable liaisons with the nuclear communities in the countries of the FSU and elsewhere in the world. This network can provide the framework for reducing research reactor risk and can offer valuable support in areas such as emergency response and health physics training. Many research reactor facilities worldwide suffer from poor quality assurance programs, lack of trained personnel, insufficient safety reviews, and limited regulatory oversight. Working in parallel with the new International Nuclear Safety and Cooperation program proposed above, the

IRRSEP can address both broader infrastructure issues and specific facility issues.

Synergies with existing Argonne work for the RERTR program and for material protection programs will be exploited to provide maximum benefit to NNSA. Cooperation with the IAEA and the U.S. Nuclear Regulatory Commission will further enhance the program’s effectiveness.

Resource requirements are given in Table IV.14. NNSA funding (NN-30) may be supplemented with funds from the U.S. Agency for International Development and from the Nonproliferation and Disarmament Fund.

Table IV.14 Integrated Research Reactor Safety Enhancement Program (\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	1.0	3.0	5.0	7.5	7.5	7.5	7.5
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	1.0	3.0	5.0	7.5	7.5	7.5	7.5
Direct Personnel	4.0	8.0	12.0	15.0	15.0	15.0	15.0

b. Infrastructure Assurance and Counterterrorism

Situation

Argonne’s work on infrastructure assurance and counterterrorism aims to assure the security and reliability of critical U.S. infrastructures — and the safety of associated populations — that are threatened by disruptions resulting from natural events, accidents, or deliberate acts such as terrorist attacks. This work addresses cyber security and technologies, as well as capabilities for detecting, combating, and recovering from chemical, biological, and nuclear terrorism (a growing national security concern addressed in the preceding Nuclear Nonproliferation and Arms Control area plan, Section IV.A.3.a). Work in these areas of homeland security directly supports DOE’s overarching national security mission.

The Laboratory’s work on infrastructure assurance and counterterrorism draws on

expertise, knowledge, technologies, and specialized research facilities developed over decades for other purposes. By leveraging the Laboratory's core science and technology competencies, this work responds to the shifting challenges facing the nation. These challenges are complicated by changes in threat profiles, weapons, targets, attackers, and motivations.

Argonne's infrastructure assurance and counterterrorism programs have annual budgets totaling approximately \$12 million. Significant components of these programs include the following:

- The Vulnerability Assessment program evaluates the safety and security of critical infrastructure by considering physical security, operations security, cyber security, and infrastructure interdependencies. The program includes comprehensive assessments and rapid surveys.
- The Energy Infrastructure Interdependencies program evaluates the interdependencies among various types of infrastructures (e.g., between electric power and natural gas or between electric power and telecommunications); the potential for cascading impacts resulting from disruptions to one or more types of infrastructures; better methods of detecting events affected by infrastructure interdependency; and improved technologies and procedures for preventing, responding to, and recovering from such events.
- The Infrastructure Outreach program increases the awareness of infrastructure owners and operators concerning security issues. This program also promotes sharing of best practices and lessons learned in infrastructure assurance.
- The Community Critical Infrastructure Protection program, in collaboration with community emergency planners and local utilities, develops plans and procedures that municipalities can use to prevent, respond to, and recover from major disruptions to energy infrastructure (e.g., that for electric power or natural gas).
- The Interior Infrastructure Protection for Chemical/Biological Attacks program

demonstrates technologies for mitigating impacts from chemical or biological attacks on interior infrastructure deemed to be at above-average risk, such as subways, airports, and public buildings.

In addition to the programs described above, the Laboratory maintains the following significant capabilities and facilities for addressing potential chemical and biological threats:

- Instruments for detecting potential chemical or biological threats in air, water, and soil, whether dispersed over kilometers or hidden in caches.
- Facilities for evaluating the effectiveness of chemical and biological monitoring methods, at both laboratory scale and field scale.
- Capabilities for determining health and environmental risk from the dispersion of chemical, biological, and nuclear weapons.
- Capabilities for evaluating the effects of agents on materials and for developing protective materials and methods of decontamination.
- Laboratories and expertise for developing prophylactic drugs and vaccines based on structural analyses of biomolecules.
- Fast-response systems for protecting first responders, decreasing exposure times, and reducing risk.
- The capability to conduct laboratory and field analyses enabling attribution of chemical or biological attacks.
- The Electron Microscopy Center, which provides high-resolution scanning electron microscopes able to examine and characterize the nanoscale embodiments likely to be used in chemical and biological detectors.
- The Multi-Bay Robotics Laboratory, which can develop robotic manipulator systems for remote work in unstructured hazardous environments.
- The Mobile Laboratory for Chemical Agent Detection, which is used to characterize chemical agent contamination in U.S. Army buildings. Samples can be analyzed on-site for

rapid turnaround, and the facility can confirm decontamination after cleanup operations.

- The Dilute Chemical Agent Facility, which is approved by the U.S. Army to Level 2 and is certified to accept agents such as soman, sarin, and lewisite. The facility is equipped for development of analytical methods, detector testing, development of decontamination technologies, and validation of transport models. This facility currently serves as an emergency response laboratory for the Environmental Protection Agency.

Other Argonne facilities also provide significant R&D capabilities for addressing potential chemical and biological threats. These include the APS and the associated Structural Biology Center and Midwest Center for Structural Genomics. Though most of the Argonne capabilities and facilities identified here were not specifically established for R&D related to chemical and biological counterterrorism, they nevertheless are significant resources for addressing currently anticipated threats.

Mission

By leveraging Argonne expertise and facilities, both physical and computational, support DOE's overarching national security mission and the complementary efforts of other federal agencies to ensure the security and reliability of our nation's critical infrastructure and reduce threats from weapons of mass destruction.

Issues and Strategy

In the area of infrastructure assurance and counterterrorism, Argonne supports the development of technologies and strategies that improve detection, mitigation, response, and recovery. As described below, the Laboratory plans to expand its work on infrastructure vulnerability and risk assessment, energy systems analysis, analysis of infrastructure interdependencies, emergency preparedness, consequence management, and protection from chemical and biological threats. These activities have been given high priority by the Office of Homeland Security and the White House Office of Science and Technology Policy,

and they are cornerstones of DOE's long-term R&D program on critical infrastructure protection.

In the area of counterterrorism, Argonne continues to expand research related to chemical and biological threat analysis, vulnerability assessment, detection and speciation, and incident response and attribution. These activities are based on Laboratory competencies that include (1) molecular biology, (2) structural analysis, (3) radiation chemistry and photochemistry, (4) catalysis and electrochemistry, and (5) chemical and biological decontamination. For example, a microchip-type sensor that employs methods for isolating and labeling RNA (ribonucleic acid) is being evaluated as part of a comparative study sponsored by the Defense Threat Reduction Agency. The Laboratory is also developing other detection methodologies that rely on biomolecular recognition, antibody pairing, or molecular fluorescence. Further current research focuses on ozone-based decontamination systems, aerosol monitoring, and risks associated with chemical warfare agents. During the coming year, Argonne will submit new threat reduction initiatives to DOE and other concerned public agencies. These initiatives are based on both Laboratory expertise and facilities such as the APS, the Structural Biology Center, and the Midwest Center for Structural Genomics.

Initiative: Infrastructure Assurance and Counterterrorism

Argonne proposes to expand its current research, development, and analysis activities in the area of critical infrastructure assurance and counterterrorism. The goal of this work for DOE and other federal agencies is to develop and apply innovative technologies, methodologies, models, and simulations that (1) will better protect critical U.S. infrastructure (including cyber-based information systems) and associated populations from disruption and (2) where disruptions do occur, will improve detection, mitigation of effects, response, and recovery. The Laboratory's capabilities are particularly relevant to the infrastructures for energy (electric power, oil, and natural gas), transportation, agriculture, water supply, information and communications, and emergency services.

This initiative responds to the executive order establishing the Office of Homeland Security and the *Executive Order on Critical Infrastructure Protection in the Information Age*, which outlines key elements of U.S. policy. The initiative is also consistent with the strategic thrust of DOE's Office of Energy Assurance, which was established in December 2001 to serve as the focus for DOE's activities in energy infrastructure assurance. Under these executive orders, DOE is the lead federal agency for assuring the continuity and viability of the nation's critical energy infrastructures.

Argonne's long history of work related to infrastructure assurance and counterterrorism — reinforced by more intensive work over the past five years for the DOE Office of Energy Assurance, the Critical Infrastructure Assurance Office, the Department of Defense, and other government organizations — provides the foundation for this initiative. The Laboratory will expand its work in the areas of vulnerability and risk assessment, energy and water systems analysis, information management, infrastructure interdependencies analysis, modeling and simulation of agent-based and complex adaptive systems, decontamination and remediation, and emergency preparedness and consequence management.

Improved technologies and capabilities are needed in all these areas to address the unprecedented range of physical and cyber threats to critical U.S. infrastructure from natural causes, accidents, and deliberate acts like the terrorist attacks on the World Trade Center and Pentagon. Argonne will particularly emphasize development of methodologies and tools for analyzing the new vulnerabilities that have arisen because various components of the nation's infrastructure have become increasingly complex, automated, physically interconnected, and logically interdependent. The White House Office of Science and Technology Policy has given high priority to research on interdependent infrastructure, and that research is a cornerstone of DOE's long-term program on critical infrastructure protection.

Argonne will continue to enhance its collaboration with other national laboratories as it conducts vulnerability surveys and assessments and develops cost-effective solutions to

infrastructure assurance and counterterrorism problems. In the area of chemical and biological threats, the Laboratory is currently leading multilaboratory teams of experts in modeling and analyzing infrastructure interdependencies and protecting civilian interior infrastructures (such as subway systems, airports, and public buildings) deemed to be at above-average risk.

Resources required for this initiative are summarized in Table IV.15. Funding will be sought from the DOE Office of Energy Assurance (GD-05), the NNSA Office of Defense Nuclear Nonproliferation (NN-20), other DOE program offices, and other federal agencies.

Table IV.15 Infrastructure Assurance and Counterterrorism (\$ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	12.0	15.0	15.0	15.0	15.0	15.0	15.0
Capital Equipment	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Construction	-	-	-	-	-	-	-
Total	12.1	15.1	15.1	15.1	15.1	15.1	15.1
Direct Personnel	60.0	75.0	75.0	75.0	75.0	75.0	75.0

4. Collaborative R&D Partnerships

Situation

Over the past decade, Argonne's technology transfer program has reinforced the Laboratory's reputation as a reliable, productive partner for industry. The R&D work conducted by the Laboratory in partnership with industry contributes strongly to DOE's strategic goals within the Department's four mission areas.

As part of the Laboratory's focus on strengthening ties with the University of Chicago, operator of Argonne, scientists are pursuing joint research projects and other forms of collaboration. In addition, the technology transfer offices at the Laboratory and the university have begun collaborating in the evaluation and licensing of Laboratory-generated intellectual property. The university brings valuable additional insight to this activity, particularly in the areas of growing research collaboration.

Mission and Vision

The mission and vision of Argonne's technology transfer program include five elements:

- License valuable intellectual property to enhance U.S. economic productivity, while providing a source of revenue for Laboratory use in compliance with the terms of the contract between DOE and the University of Chicago for the management and operation of Argonne.
- Enhance Argonne's R&D programs and increase their funding through interactions with non-DOE government entities and with private institutions, including industry and academia.
- Enhance the worldwide competitiveness of U.S. industry through cost-shared and reimbursable R&D performed by the Laboratory.
- Foster utilization of Argonne's R&D.
- Deliver and leverage a technology transfer program — including policies, processes, and results — that increases returns to Argonne and significantly contributes to the Laboratory's fulfillment of its mission and strategic goals. To this end, (1) improve Argonne's technology transfer policies and processes and (2) increase programmatic and stakeholder satisfaction with the technology transfer program and the associated construction, delivery, and execution of technology transfer solutions.

Issues and Strategies

Numerous cooperative R&D agreements (CRADAs) are supported through Laboratory programmatic activities, and Argonne is increasingly using work-for-others contracts for industrial agreements. Full funds-in CRADAs are also used to advantage to develop cooperative research partnerships, when DOE funding for Laboratory efforts is not available. Argonne continues to increase the precommercial R&D that it performs for private industry.

For further information about technology transfer at Argonne, see Supplement 2.

B. Laboratory Directed R&D Program

Laboratory Directed Research and Development (LDRD) funds creative and innovative R&D projects at Argonne. Selection of projects is the responsibility of the laboratory director. The objectives of LDRD are to stimulate innovation and creativity, to continuously renew the scientific and technological vitality of the Laboratory, and to respond to rapidly emerging R&D opportunities. The program enhances Argonne's ability to attract and retain the high-caliber scientists and engineers essential for undertaking the Laboratory's missions for DOE and the nation. In addition, LDRD helps ensure that the Laboratory provides scientific and technical leadership in mission-related fields.

Argonne's primary project selection criteria are scientific and technical excellence, relationship to Laboratory strategic goals and objectives, innovativeness and cross-disciplinary character, expected contributions from the results, and prospects for continuation under programmatic support. Each year the laboratory director designates portions of the LDRD budget for support of particular types of projects. Categories include (1) competitive grants initiated by a principal investigator or a team on any mission-related topic and (2) projects directly related to the Laboratory's strategic initiatives. The immediate objectives of Argonne's LDRD portfolio are (1) to reinforce the Laboratory's R&D planning by supporting its mission and strategic view (as described in Chapter II of this *Institutional Plan*), (2) to enrich the Laboratory's technical capabilities, (3) to encourage innovation and creativity by technical staff through the development of new concepts and principles and the undertaking of projects having high risk but potentially high reward, and (4) to exploit the Laboratory's technical potential for the benefit of the nation. In addition, the LDRD program has the very important outcome of enhancing the morale and vitality of the Laboratory's scientific and technical staff. Researchers' enthusiasm is nurtured by the knowledge that good new ideas, even those well beyond existing programs, are eligible to compete for the immediate funding they need.

Argonne's LDRD program supports promising novel and innovative projects wherever they may appear across the broad spectrum of science and technology relevant to current or prospective Laboratory missions. A report of accomplishments across the entire LDRD program is made to DOE each year. Some notable recent accomplishments include the following:

- Development of super-hard low-friction coatings for wear surfaces in diesel engines
- Design of high-throughput robotic devices for rapid characterization of biomolecular species
- Design of solid-state-based neutron detectors for survey and analysis of radiation fields produced by accelerators and other sources
- Ultra-miniaturization of multilayered ferroelectric capacitors for application to next-generation high-density data storage and nonvolatile memories
- Multivariate analysis of technical and economic factors affecting the transition from current-day power reactors to future-generation designs
- Development of a method based on gamma rays for the highly selective, highly sensitive detection of fissile materials
- Development and application of a scanning near-field magneto-optical microscope
- High-fidelity simulation of the human spine using parallel computing platforms
- Demonstration that direct etching with a focused-ion beam offers a feasible, possibly better method of fabricating high-resolution, high-efficiency microfocusing x-ray zone plates for use in scanning x-ray microprobes at synchrotron light sources

The larger component of LDRD emphasizes R&D aligned with Laboratory strategic initiatives, as reflected in this *Institutional Plan*. Strategic goals are periodically revised and reevaluated, as required. Existing staff expertise naturally causes a substantial number of employee-suggested

LDRD projects to fall under the various high-priority initiative areas, so they can receive a correspondingly high priority in the proposal selection process. As discussed in Chapter III, current major Laboratory initiative areas include Nanosciences and Nanotechnology, the Rare Isotope Accelerator, Functional Genomics, Petaflops Computing and Computational Science, and Advanced Nuclear Fuel Cycle.

Several LDRD projects will be supported under the auspices of the Director's Competitive Grants component of the LDRD program. This component provides a direct avenue for single investigators and small multidisciplinary teams to propose projects to the laboratory director that do not fall within the Laboratory's defined strategic initiative areas, but that have high scientific or technical merit and are at the forefront of their fields. A Director's Review Committee, comprising scientists and engineers spanning the breadth of Argonne disciplines and programs, subjects Competitive Grants proposals to a thorough and highly competitive merit review. The resulting ranking is used by the laboratory director to select the winning proposals.

The LDRD program is funded Laboratory-wide through Argonne's indirect budget. As part of its LDRD planning before each fiscal year begins, the Laboratory proposes to DOE a maximum total LDRD expenditure. As indicated in Table IV.16, for FY 2002-FY 2004 this upper limit generally approximates 4.5% to 5.0% of projected total operating plus equipment funds for the Laboratory.

Table IV.16 Laboratory Directed R&D Funding (\$ in millions)

	FY01 ^a	FY02 ^b	FY03 ^c	FY04 ^c
	20.9	20.9	21.5	22.5

^a Actual expenditures.

^b Authorized maximum expenditures for the LDRD program.

^c Planned maximum expenditures for the LDRD program.

V. Operations and Infrastructure

Strategic Plan

The Laboratory's fourth strategic objective is stated in Chapter II: "The University of Chicago and Argonne will continuously improve the cost-effectiveness, management, and operations of the Laboratory." This chapter presents strategic plans for the following areas of operations and infrastructure at Argonne: human capital; environment, safety, and health; site and facilities; integrated safeguards and security management; information management; communications, outreach, and community relations; performance management; and cost-effectiveness of support functions. The chapter begins with general statements of mission, situation, and goals and strategies for operations and infrastructure.

General Mission

Operations infrastructure and support activities are crucial to the achievement of Argonne's R&D missions. Operations organizations work as partners with the Laboratory's R&D programs, providing cost-effective, customer-focused infrastructure and services that enable the creation of world-class science, technology, and service products. Maintaining this institutional environment and support structure requires effective, efficient accomplishment of the following major mission elements:

- Provide administrative, business, and technical support to the Laboratory's science and technology programs.
- Ensure the recruitment, development, and support of top-caliber, diverse human capital.
- Facilitate and support safety and health in the workplace.
- Provide environmental stewardship of the Laboratory's sites.
- Manage and operate the Laboratory's physical plant; upgrade general plant facilities or construct new facilities as required. Provide a safe, secure work site that protects the

Laboratory's people, facilities, physical property, and intellectual property.

General Situation Analysis

Because operations and infrastructure are funded as a charge to the total program funding received by the Laboratory, there is always great incentive to reduce these overhead costs while still maintaining the effectiveness and quality of operations and services. Every overhead dollar saved is an additional dollar for direct funding of research programs.

The terrorist attacks of September 11, 2001, have had a profound effect on the DOE laboratory system. One of the most evident responses has been increased security at laboratory sites. Argonne achieved enhanced security with minimal disruption of its ability to carry out its R&D missions. In general, Argonne has conducted its efforts in security, counterintelligence, and cyber protection in an integrated and highly coordinated fashion. This integrated management of safeguards and security is similar to the Laboratory's earlier establishment of integrated safety management.

General Goals and Strategies

The goal of Argonne's operations infrastructure and support functions is to conduct all work and operate facilities cost-effectively and with distinction so as to achieve integration with and support of its missions in science, technology, energy, and environmental quality, while fully protecting its workers, users of its facilities, the public, and the environment. The Laboratory continually strives to increase the efficiency of its operations and support units while maintaining their effectiveness and quality. The performance-based contract between the University of Chicago and DOE, hereafter referred to as the *Prime Contract*, provides a system for encouraging continuous improvement in Argonne's operational

functions (as discussed further in Section V.G). With collaboration and support from DOE's Chicago Operations and Argonne Area Offices, the Laboratory continues to refine a full range of best business practices.

A. Human Capital

Situation

The quality of technical staff is a primary determinant of the performance of an R&D laboratory. Argonne's human resources strategy is designed to develop strong leadership, to support a creative and diverse workforce, and to recruit and develop the talent needed to implement the Laboratory's programmatic activities and initiatives.

Human resources management at Argonne is conducted as a partnership between the Laboratory's programmatic and operations organizations and the central Human Resources Division. Critical to the success of this effort is a focus on Laboratory policies, programs, and initiatives that influence an individual's decision to join the Laboratory, that help shape the working environment for those making a career at Argonne, that contribute to the well-being of employees — even after they retire — through important benefits such as health insurance and retirement income, and that comply with federal and state regulations.

Total commitment to equal opportunity for all people is a fundamental Laboratory policy. Argonne values the diverse cultural and ethnic backgrounds of its employees and strives to create an environment that capitalizes on these differences as one means of maintaining a high-performance workforce.

Goals

The goal of Argonne's human capital management is to support the strategic objectives of the Laboratory's programmatic and operations organizations by developing and implementing programs that attract, develop, compensate, and help retain a qualified and diverse staff. Specific objectives include the following:

- Directly link and integrate centralized human resources strategies with the strategic needs of division managers.
- Improve the quality of work life to foster a work environment that promotes staff satisfaction, individual contribution, and organizational effectiveness.
- Maintain a compensation policy that is competitive with policies at peer organizations and that rewards superior performance.
- Promote the commitment of managers at all levels to equal opportunity, affirmative action, and diversity.
- Develop Laboratory leadership and staff capabilities through targeted management training and skill development opportunities.
- Provide services that promote the well-being and productivity of Argonne employees.

Strategies

The key to effectively integrating centralized human resources strategies with the needs of individual programmatic and operations divisions is frequent dialogue with division managers, particularly regarding opportunities for centralized services beyond purely administrative functions. To enhance communication and achieve this integration, the Laboratory uses formal management surveys, input from human resources liaisons within the divisions, and direct dialogue with division managers. During regularly scheduled one-on-one meetings, division directors and human resources representatives discuss personnel and recruitment needs, training, diversity targets, and the division's general human capital needs.

Achievement of Laboratory goals requires top-quality staff who find personal and professional fulfillment in their work (Table V.1). Argonne's success in recruiting and developing high-caliber employees starts with recruiting the best and the brightest, including people from diverse backgrounds. In FY 2001 Argonne recruiters participated in 16 job fairs, through which they directly contacted over 900 potential new hires.

Table V.1 Academic Degrees of Argonne Staff^a

Occupational Category	Total	PhD	MS/MA	BS/BA	Other ^b
Officials and Managers	513	222	129	96	66
Scientists	638	328	127	126	57
Engineers	618	220	159	150	89
Managers and Administrators	258	23	54	100	81
Technicians	552	1	6	70	475
All Others	1,000	0	2	60	938
Grand Total	3,579	794	477	602	1,706

^aNumber of full- and part-time regular employees as of September 30, 2001.

^bAssociate level degree or less.

Argonne is committed to strengthening the vitality, quality, and diversity of its workforce. Maintenance of a competitive compensation structure is important in the Laboratory's competition for critical talent. Argonne manages all components of compensation — base pay, merit increases, compensation supplements, and promotion-related increases — as a coordinated whole. Each employee's compensation (apart from

fringe benefits) is linked to achieved performance, as evaluated under the Laboratory's appraisal process. That process focuses on sustained performance and compensation relative to peers and the external market. In early FY 2002, after an in-depth analysis, DOE certified Argonne's compensation system and characterized it as one "that demonstrates continuous improvement, creativity, and effectiveness."

Total commitment to equal opportunity for all individuals is a fundamental Laboratory policy (Table V.2). The Laboratory's annual *Affirmative Action Plan* gives Argonne managers a summary of previous accomplishments and a blueprint for the future. The importance of increasing the low percentage of women and underrepresented minorities in scientific, engineering, and upper management is fully appreciated. However, this process is slow when constant-dollar Laboratory budgets are flat or declining. In general, supervisors are held accountable for progress in this area. In FY 2001, job postings and recruitment ads were placed in eight magazines

Table V.2 Equal Employment Opportunity at Argonne^a

Occupational Category	Total		Minority Total		White	
	Male	Female	Male	Female	Male	Female
Officials and Managers	414	99	33	9	381	90
Scientists and Engineers	1,085	171	161	30	924	141
Managers and Administrators	112	146	7	22	105	124
Technicians	486	66	45	10	441	56
Clerical Workers	18	434	3	67	15	367
Craftsmen and Laborers	341	37	64	15	277	22
Service Workers	124	46	28	13	96	33
Totals	2,580	999	341	166	2,239	833

Occupational Category	African-American		Hispanic		Native American		Asian	
	Male	Female	Male	Female	Male	Female	Male	Female
Officials and Managers	5	4	4	1	1	0	23	4
Scientists and Engineers	17	2	14	4	2	0	128	24
Managers and Administrators	2	9	3	5	0	1	2	7
Technicians	17	3	17	1	2	1	9	5
Clerical Workers	2	31	1	25	0	2	0	9
Craftsmen and Laborers	47	12	13	2	1	1	3	0
Service Workers	18	6	4	6	2	1	4	0
Totals	108	67	56	44	8	6	169	49

^aIncludes both full-time and part-time regular employees as of September 30, 2001.

and web sites that target minority job candidates, an increase from six in FY 2000.

Argonne supplements the formal education of its employees with performance-enhancing training. Course offerings are based both on assessment of professional development needs and on compliance with DOE directives. The Laboratory offers courses on a wide range of subjects, including supervisory skills, team building, project management, presentation skills, and R&D proposal development. It recently introduced the *Management Minute*, a quarterly online newsletter designed to improve the leadership skills of Laboratory managers and supervisors. In addition, to provide just-in-time training for supervisors and employees, the Laboratory is piloting *The OnLine Learning Center*, a web-based training library offering over 900 courses.

Additional Argonne programs that promote the well-being and productivity of employees include health screening and wellness programs, financial education programs, and programs for dealing with life and family issues. Examples include seminars on financial topics such as funding education, individual retirement accounts, and tax strategies; a seven-part lecture series on complementary and alternative medicine; an elder care fair; and a health fair.

To increase the effectiveness and quality of human resources information and to reduce costs, Argonne is taking advantage of new electronic approaches to information management and reducing its dependence on traditional paper documents. For example, a new online open enrollment system was introduced as the first phase of a larger employee self-service capability. The new system allows employees to view current benefits, research available benefit options, and make changes to health care plans or flexible spending accounts. In another example, the Laboratory's online systems for administering merit review and position descriptions allow programmatic divisions to manage staffing and compensation planning more effectively and efficiently. In addition, the Laboratory's intranet now provides electronic versions of the employee handbook, policy and procedures manuals, and benefit plan descriptions, along with information on the historical performance of retirement funds.

B. Environment, Safety, and Health

Situation

Protection of the environment, safety, and health (ES&H) is a fundamental value for Argonne. Safety statistics confirm that Argonne is a safe place to work, and both analysis and experience indicate that Laboratory operations have minimal environmental impact. For example, as Figure V.1 shows, for the past several years the Laboratory has maintained case rates for recordable and lost/restricted workdays — as defined by the Occupational Safety and Health Administration — that are low relative to comparable industry rates. Argonne's FY 2001 *Self Assessment* explains Argonne's progress in ES&H in detail (URL: www.ipd.anl.gov/cpmr/text.html).

Argonne recognizes the need for continuous evaluation and improvement in its ES&H programs, and it has firmly embraced its integrated safety management (ISM) policy as an operating philosophy. ISM maintains employee attention to essential ES&H issues, goals, and ideas. The structure of the ES&H program is described in depth in the *Integrated Safety Management (ISM) Program Description, Revision 6*, dated February 25, 2002 (URL: <http://www.anl.gov/ESH/main/ism/pdf/ISM-rev6.pdf>).

Argonne's ISM program includes investigation of incidents and proactive management of Worker's Compensation claims through

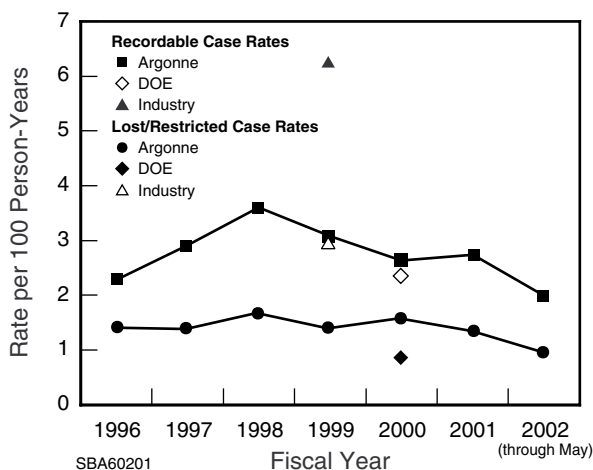


Figure V.1 Case Rates for Recordable and Lost or Restricted Workdays

coordination of medical department interventions and ES&H analyses with investigations of causes by line managers. The central goal is to protect employees from occupationally related injury or illness.

During FY 2002, the Laboratory's medical department will continue to support DOE's Beryllium Worker Protection Program and will offer beryllium blood lymphocyte testing to voluntarily participating employees. In cooperation with DOE, the Laboratory is assisting the Oak Ridge Institute for Science and Education (ORISE) in offering former employees an opportunity to participate in ORISE's Beryllium Medical Surveillance Program. Argonne strongly supports both of these beryllium-related programs.

Goals and Objectives

The overall goal of Argonne's ES&H program is to ensure that all activities are conducted (1) with minimal and measured adverse impacts to personnel and the environment and (2) within regulatory constraints. The central tenet of ISM throughout Argonne is line management responsibility and accountability, in conjunction with the expectation that each worker is involved in ISM and accepts responsibility for implementing and promoting it.

To strive for continuous improvement in achieving this overall goal, Argonne has established five specific strategic objectives:

- Conduct an ES&H program that effectively supports R&D activities and is judged to be "outstanding" by both DOE and peer laboratories.
- Promote assessment planning by each major research and support organization, and ensure that their assessment plans include the proper mix of self-assessment and independent assessment to address appropriately the broad range of relevant ES&H issues.
- Establish and track appropriate indicators of ES&H performance that help promote improvements to the Laboratory's safety culture and research performance.
- Enhance the Laboratory's current environmental management system to support the goals of the *Greening of the Government*

through Leadership in Environmental Management (Executive Order 13148) and the associated DOE Notice N 450.4 by, in part, establishing clear environmental policies, interpreting the environmental management system as part of the ISM program, and continuing to work toward good relations with stakeholders and surrounding communities.

- Establish and maintain a long-term stewardship program for environmental monitoring of Laboratory remediation sites.

Strategies

Argonne regularly (1) evaluates its ES&H requirement documents to ensure that they reflect changing regulations, (2) implements the documented requirements, and (3) assesses various ES&H program elements to measure implementation of requirements and to promote continuous improvement.

The Laboratory uses limited available resources to address ES&H concerns that pose the greater risks. However, setting priorities often requires considerable judgment in such areas as promoting continuous improvement in the Laboratory's safety culture, in the performance metrics system, and in other ES&H systems. Argonne relies on the creativity of its personnel to establish ES&H requirements and implementation strategies that are consistent with the risks presented by the work being done. Specific needs are documented as part of the Laboratory's *ES&H and Infrastructure (ESH&I) Management Plan* process.

Argonne will continue to pursue its ES&H goals through its strategic objectives by using established systems operating pervasively under the ISM philosophy. The Laboratory will continue to monitor its ES&H performance by using *Prime Contract* performance measures, other germane indicators, and its formal assessment program. The Laboratory will continue to conduct frequent monitoring, surveillance, and evaluation in the workplace in order to implement specific ES&H performance measures and to address ES&H issues generally.

Argonne uses a structured approach to ensure that facility conditions affecting ES&H are

appropriately identified and prioritized among all Laboratory infrastructure needs. The Laboratory's *ESH&I Management Plan* addresses required reporting to DOE by means of a detailed prioritization of all ESH&I projects. Projects related to ES&H include life safety and fire protection upgrades, environmental restoration, wetlands management, mechanical and control systems, an electrical service upgrade line item, decontamination and decommissioning activities, and a facility to store remotely handled transuranic waste for final disposal.

Argonne's assessment program includes (1) assessments conducted by line organization managers to evaluate their own processes; (2) other self-assessments conducted by line organizations to evaluate specific topics; and (3) independent assessments conducted by Laboratory organizations or committees, by committees of the University of Chicago, by DOE, or by other regulatory agencies or stakeholders. On the basis of the results of these assessments and other evaluations, Argonne establishes appropriate corrective action plans. Where corrective actions require significant resources and changes to the Laboratory infrastructure, Argonne uses the formal *ESH&I Management Plan* process to identify and prioritize resource allocation.

To address the requirements in DOE Notice N 450.4, Argonne plans to include existing program elements in an environmental program description that is integrated with the current ISM program description. The environmental program description will explain (1) how the Laboratory's work meets DOE regulatory requirements and environmental regulations such as the Resource Conservation and Recovery Act and the Comprehensive Environmental Response, Compensation, and Recovery Act and (2) ongoing Laboratory programs that promote pollution prevention, waste minimization, long-term stewardship, community relations, and continuous improvement.

C. Site and Facilities

Situation

Argonne conducts basic and technology-directed research at two sites owned by DOE.

Argonne-East is located on a 1,500-acre site in DuPage County, Illinois, about 25 miles southwest of Chicago. Argonne-West is located on an 800-acre tract within the Idaho National Engineering and Environmental Laboratory (INEEL), about 35 miles west of Idaho Falls, Idaho. Argonne-West is devoted mainly to R&D on nuclear technologies and nuclear environmental management.

The physical infrastructure at Argonne-East contains 4.8 million square feet of floor space, including 77 thousand square feet of nearby leased space. The facilities, valued at approximately \$1.9 billion, currently accommodate about 4,800 persons (including DOE employees, contractors, and guests). Throughout the year, over 2,000 other researchers use the Laboratory's scientific facilities as visitors or collaborators. Argonne-East facilities are nearly 99% occupied.

Argonne-West contains 581,000 square feet of floor space, with an estimated replacement value of \$438 million. The site currently accommodates about 690 persons. Recent renovations and continuing maintenance of major facilities are enabling Argonne-West to pursue important research on nuclear technology for DOE. Program sponsors other than DOE-Nuclear Energy are charged for facility utilization in a manner similar to the space use charge-back system at Argonne-East. Site services such as fire protection and dosimetry are purchased from the site contractor for INEEL.

Supplement 3 (located near the end of this document) provides additional information on Argonne's sites and facilities, including plans for infrastructure and for the rehabilitation and modernization of facilities.

Vision

Argonne will retool its physical setting to achieve a 21st-century infrastructure having appropriately configured research facilities that provide reliable, safe, secure, efficient, attractive working environments suitable for world-class science, engineering, and technical services.

Issues and Strategies

In the area of site and facilities, the principal challenges Argonne is addressing are the normal aging of buildings and infrastructure and a substantial need for upgraded laboratory facilities to meet the challenges of the 21st century. As Figure V.2 shows, 41% of Argonne-East facilities are over 40 years old, while at Argonne-West 65% of space is over 30 years old.

Argonne-East

In recent years Argonne-East has made substantial progress toward the rehabilitation and replacement of its facilities. However, as Figure V.3 shows, an estimated 39% of the site's occupied facilities are still in need of major

rehabilitation or upgrades. Forty-three percent of the facilities are considered to be in adequate condition, while 4% of laboratory floor space is in substandard facilities that require removal.

Over the infrastructure planning horizon, new programmatic facilities are likely to expand the base of modern, efficient space at Argonne-East. Nevertheless, substantial need for rehabilitation of older facilities will remain.

Strategic modernization of Argonne-East facilities centers on three coordinated, phased upgrade projects addressing (1) building electrical systems, (2) building mechanical and control systems, and (3) laboratory space upgrades. The work scope of each project phase is based on priorities established through the Laboratory's Condition Assessment Survey process.

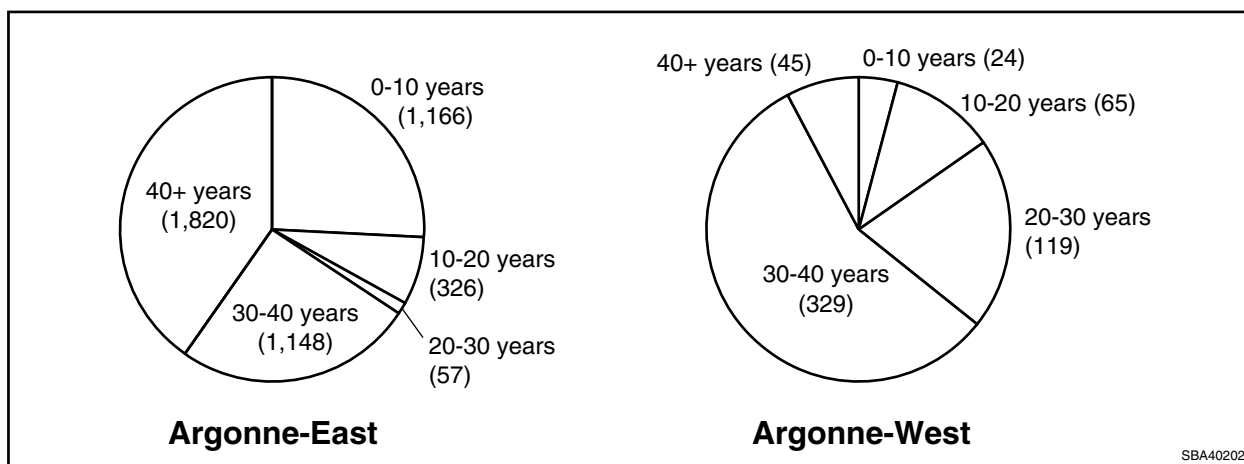


Figure V.2 Age of Argonne Facilities (values in thousands of gross square feet)

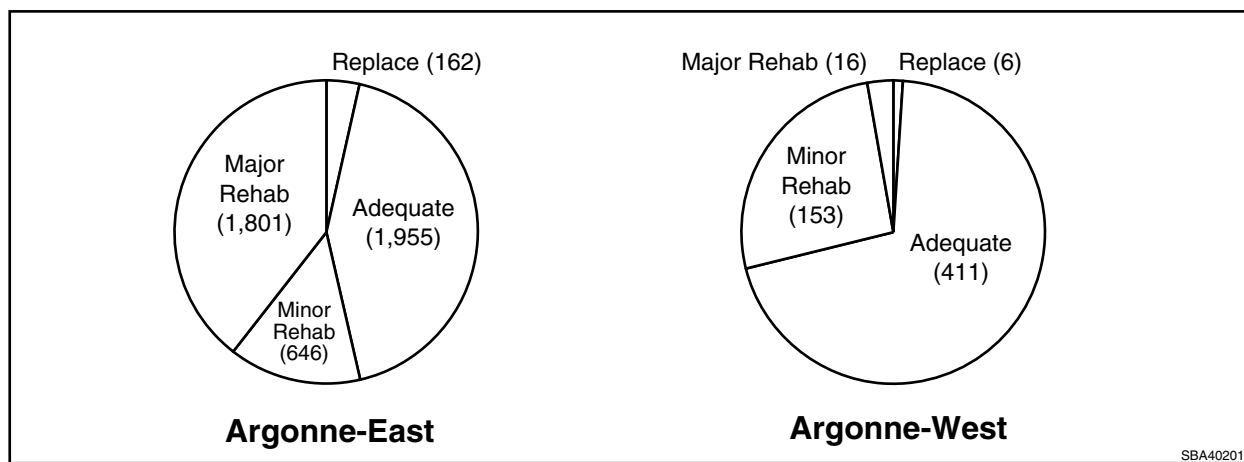


Figure V.3 Condition of Argonne Facilities (values in thousands of gross square feet)

In general, Argonne-East upgrades a building's electrical system to support greater mechanical and functional power and lighting loads and to allow more extensive use of equipment. Improved mechanical and control equipment and upgraded mechanical, distribution, and collection systems are installed as the basis for a building utility support network that is more flexible and adaptable.

In coordination with these efforts, Argonne-East plans significant upgrades to laboratory and office spaces to bring them to today's standards. Modernization is planned for 12 buildings providing 2 million gross square feet of space. The site's new central supply facility exemplifies application of the principles of sustainable design and facilities integration, which will be a hallmark of planned infrastructure upgrades.

Argonne-East also needs new facilities. A general purpose laboratory/office building is needed to relocate research during the modernization of older buildings and wings. Concurrent plans call for a new, centralized computing facility to enable the data sharing and visualization capabilities being included in upgrades throughout the Laboratory and also to provide supporting general purpose equipment. In addition, a new high bay facility is needed for general program work.

Roof replacement is a major Argonne-East initiative as the roofs of major buildings near the end of their 20-year design life and the frequency of repairs increases. Similarly, deteriorating roads and parking lots will require substantial investment over the next 5 years.

Other site improvements also have high priority. The Argonne-East telecommunications system requires immediate attention to achieve the required conversion to digital equipment by January 2005. The proposed Phase V Fire Safety Improvements project will reduce the potential for property loss. In addition, the site's central heating plant will require a major upgrade of its auxiliary systems and equipment by FY 2008.

To achieve a 21st-century infrastructure, Argonne-East requires total capital funds of approximately \$294 million in FY 2003 through FY 2008. (See Supplement 3 for details.) Figure V.4 shows the distribution of the total

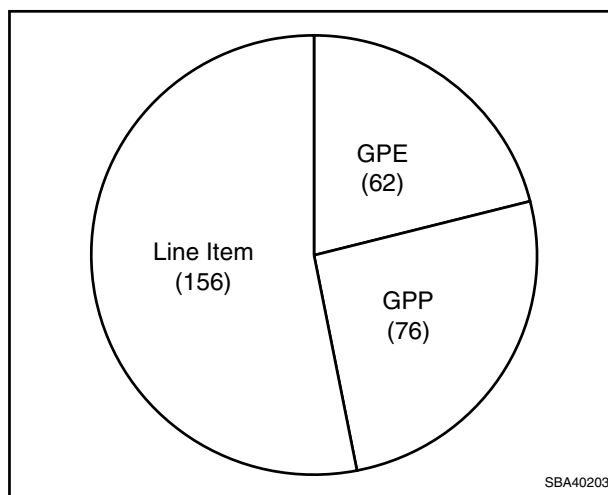


Figure V.4 Six-Year Capital Funding Requirement for Argonne-East (\$ million)

between General Purpose Equipment (GPE), General Plant Projects (GPP), and line-item funding. In addition, the site requires a total of \$58 million in direct operational funding from the DOE Office of Science to undertake needed environmental and demolition work not currently supported by funding from the DOE-Environmental Management program.

Argonne-West

In recent years Argonne-West has made substantial progress toward maintaining the condition of its facilities. However, as Figure V.3 shows, an estimated 9% of the site's occupied space still needs major rehabilitation or upgrades, while 20% needs minor rehabilitation. Seventy percent of occupied space is considered to be in adequate condition. Only 1% of space is substandard and requires removal.

Strategic modernization of Argonne-West facilities basically uses the coordinated, phased approach to upgrades also used at Argonne-East. Priorities established through the Laboratory's Condition Assessment Survey indicate that upgrades are needed for the site's building electrical systems and its mechanical and control systems. In addition, Argonne-West plans significant upgrades to facility and office space to achieve current standards.

Argonne-West also needs new facilities. A general purpose office building is needed to replace eight “temporary” office buildings presently housing administrative, engineering, and DOE personnel.

Roof replacement is a major Argonne-West initiative as the roofs of major buildings near the end of their design life and the frequency of repairs increases. Similarly, deteriorating sidewalks will require substantial investment over the next five years.

To achieve a 21st-century infrastructure, Argonne-West requires total capital funds (GPP and GPE) of approximately \$11 million in FY 2003 through FY 2008. In addition, Argonne-West requires direct operational funding of \$6 million per year for real property maintenance.

Closure of the Experimental Breeder Reactor-II at Argonne-West is scheduled for completion in 2002. This work will place the facility in a safe, stable condition requiring minimal surveillance and maintenance for an indefinite period prior to eventual decontamination and decommissioning. Nevertheless, the facility is contaminated and should be considered a candidate for transfer to DOE-Environmental Management for cleanup.

The demand for hot cell and laboratory space at Argonne-West is particularly high. A major focus is providing the facilities and infrastructure needed to deal with spent fuel and nuclear waste (for the electrometallurgical fuel treatment program, for example).

Argonne-West is planning construction of a major hot cell facility needed to handle and process for disposal remotely handled mixed transuranic waste from both Argonne-West and INEEL. Disposal of this waste outside Idaho by the year 2018 is required by the court-ordered settlement agreement between DOE and the state of Idaho. Moreover, after 2018 this facility will be a cornerstone — along with the Hot Fuel Examination Facility and the Fuel Conditioning Facility — for a much needed DOE hot cell center that will (1) develop base technologies to address problems associated with disposal of remotely handled waste and (2) support research to improve nuclear fuels and materials.

D. Integrated Safeguards and Security Management

Situation

Argonne has a responsibility to provide a safe and secure environment for all its employees and visitors. Facilities, equipment, and information must be protected from theft, disruption, or misuse. Argonne-West protects significant quantities of special nuclear material. (Argonne-East possesses only small quantities of nuclear materials for limited research use.) Detection and prevention of electronic intrusion are among the more challenging aspects of security facing the Laboratory.

Argonne’s mission predominantly involves fundamental research or technology development, with results disseminated openly and shared with the scientific community or made available to private industry. The quality of such work depends intrinsically on open dialogue and exchange of information. To serve its mission, the Laboratory each year hosts thousands of foreign visitors and assignees, with whom it encourages active information exchange. The Laboratory also participates in several officially sanctioned training programs with Russia, other countries of the former Soviet Union, and the International Atomic Energy Agency. As a key player in leading-edge cooperative R&D with U.S. industry, Argonne often conducts research involving vital commercial interests.

Most Argonne work is exempt from export regulation and is constrained only by prudent management to assure accuracy and proper disclosure. Nevertheless, certain Laboratory undertakings are subject to some combination of export control, classification, proprietary interest, and other restrictions on dissemination of results.

Objectives

The Argonne-West Reactor Program Services Division, the Argonne-East Office of Safeguards and Security, the chief information officer, and the Office of Counterintelligence mutually

integrate their efforts to ensure the following results:

- Site access controls provide a safe, secure working environment for employees; for guests; and for the large, diverse community of visiting researchers using Laboratory facilities.
- An active cyber security program makes electronic information freely and readily accessible to authorized users while protecting the information against disruption, compromise, destruction, or misuse.
- Appropriate processes and procedures are in place to assure controlled access to classified and proprietary information.
- Active awareness training and information programs educate all employees in how to maintain and enhance Laboratory security.
- Appropriate controls and systems protect special nuclear materials, classified matter, and high-value property against theft, diversion, or destruction.

Argonne's security organizations work closely with each other and with senior management to ensure that policies and systems are optimized to protect Laboratory assets while enabling scientific progress.

Strategies

Protection of physical assets at Argonne requires a combination of access controls and other security measures. Protecting equipment, hardware, and materials at Argonne-East generally involves practices characteristic of industrial security. The protective forces at the Argonne-East site are trained security professionals who operate under contract to the Laboratory. The Laboratory manages and administers these forces, which include unarmed, trained security officers. The Laboratory is responsible for providing security for the entire Argonne-East site, including DOE offices and the New Brunswick Laboratory.

The larger quantities of special nuclear material at Argonne-West necessitate more extensive access controls and security force capabilities. The site's security force is armed and certified by DOE to the SPO-II level. Some

officers are certified to the SPO-III level and are assigned to special response teams. All members of the Argonne-West security force are regular Laboratory employees. The site also employs physical protection systems such as sensors, alarms, physical barriers, entry control devices, and surveillance systems. An extensive, documented vulnerability analysis is under way, utilizing DOE's *Design Basis Threat*.

Protection of intellectual property involves implementing an integrated network of policies, procedures, and practices. Argonne meets all federal regulations relating to national security and export control, including all applicable DOE regulations. Key to the Laboratory's program are access control and awareness training, supplemented by an extensive cyber security program for both classified and unclassified computing and by counterintelligence activities. A graded approach is used to determine the type and intensity of protective measures implemented.

Argonne's cyber security program is designed to prevent, at both Laboratory sites, unauthorized access to information and disruption of information systems, with minimal disturbance of open scientific discourse. The program identifies information having national security interest; information whose distribution should be limited, from the perspective of Laboratory management, operations, and business activities; commercial or proprietary information; and research information that has not yet been approved for release. Access to all information other than general public-use information is protected by graded or tiered access-control mechanisms and is systematically monitored. Encryption is used where appropriate. Reporting and tracking capabilities are employed locally to anticipate cyber security problems before they occur, and a full response capability is maintained. Cyber security systems are evaluated and tested regularly, and improvements are deployed continuously to counteract changing threats. The Laboratory provides computer security training to all of its computer users.

At both sites, Argonne maintains an Operations Security (OPSEC) program designed to minimize the ability of foreign intelligence agencies or other adversaries to exploit sensitive DOE activities or information and to prevent the inadvertent disclosure of such information. The

OPSEC program is supported and overseen by an OPSEC working group, which represents both programmatic and operations organizations. Support by the working group includes (1) development and review of the site's *OPSEC Program Plan*, *Critical Program Information*, and *Comprehensive Local Threat Statement*; (2) participation of group members in OPSEC assessments; and (3) review of assessment results and countermeasures. The OPSEC working group also provides oversight and advice to senior management on the Laboratory's broader safeguards and security program, as well as advice to program managers.

The Laboratory has a robust classification program at each site to establish policies and procedures that ensure the proper identification and classification of information that requires protection in the interest of national security. The classification officer at each site develops and implements training programs for persons working with classified information. Trained, knowledgeable persons are certified as "authorized derivative classifiers" to support both individual projects and routine Laboratory work. These individuals and classification officers review potentially sensitive information to ensure that all classified information is identified and protected.

The main objective of Argonne's counter-intelligence (CI) program is to support DOE's CI program generally and the Laboratory specifically, by detecting, counteracting, and preventing political, economic, industrial, and military espionage and other clandestine intelligence-gathering activities directed at Argonne personnel, information, activities, facilities, and technologies. The CI program is designed to deter and neutralize intelligence gathering on behalf of foreign governments or others. At both Argonne sites, this multifaceted program encompasses CI awareness, CI aspects of cyber security, CI-related investigations, and threat analysis, as well as liaison with federal, state, and local law enforcement and the U.S. intelligence community.

The CI program at each Argonne site supports and strengthens the Laboratory's overall safeguards and security program by working in concert with programs addressing security education and awareness, foreign visits and

assignments, foreign travel, cyber security, operations security, information security, personnel security, nuclear material control and accountability, and physical security.

E. Information Management

Information management at Argonne emphasizes the effective development, communication, and management of scientific, technical, operational, and administrative information. Because of the broad importance of information management and its associated infrastructure, those two intimately related areas are managed both as integral parts of research programs and as institutional functions.

Vision

Argonne will maintain high-performance, cost-effective infrastructure and services in information management. These capabilities will support excellence and efficiency in the Laboratory's R&D program by providing for optimal use of text, data, images, and sound in appropriate media. Employees will be proficient in the computer-related skills needed to realize fully the benefits from the Laboratory's information systems.

1. Information Technology

Situation

Argonne provides a wide range of central services to support the digital collection, creation, dissemination, and archiving of R&D and business information. Service organizations also operate a Laboratory-wide spectrum of systems and services for software development and application, telecommunications, and computing. Strategic planning, funding, and coordinated management for the Laboratory's information infrastructure and systems are addressed collaboratively by policy and planning groups supported by review and implementation teams.

To ensure that the Laboratory's information management infrastructure evolves as required to support programmatic needs, Argonne leads or

collaborates in various national initiatives in information access, networking, and telecommunications, particularly through pilot projects that test the applicability of new information technologies to DOE-funded R&D. The Laboratory maintains national network connections, such as ESnet (the DOE Energy Sciences Network) and MREN (a high-speed test network in the Chicago metropolitan area, recently upgraded from 155 megabits per second to 622 megabits per second). These external networks interface with local Argonne networks and help to position the Laboratory as a major player in national networking initiatives. Sophisticated network intrusion detection capabilities provide for identification and dynamic blocking of intruders and the detection of cyber security anomalies in network traffic. Each day, as many as 300,000 potential intruder alarms are scrutinized, and a terabyte of network traffic data is analyzed for cyber security anomalies.

Goals and Objectives

The primary goal of information technology at Argonne is to maximize the ease and effectiveness with which information is acquired, created, communicated, stored, retrieved, and applied, both within the Laboratory and with the Laboratory's partners in government, academia, and the private sector. The Laboratory's operations organizations have the following supporting objectives:

- Maintain an efficient, standards-based infrastructure for communications, computer networking, and information systems.
- Continually enhance services that facilitate internal and external information exchange.
- Conduct education programs that upgrade the computer literacy and skills of Laboratory employees.
- Maintain a strong cyber security infrastructure and program.
- Maintain strong core competencies in state-of-the-art and emerging information technologies that enable timely deployment of systems and services tailored to mission needs.

- Evaluate emerging information technologies through aggressive use of demonstrations and pilot projects.

Strategies

Argonne's near-term strategies for information technology focus on the Laboratory's needs for (1) secure, high-performance telecommunications and networking infrastructure and (2) high-quality Laboratory-wide information systems and services.

Key strategies for achieving secure, high-performance, cost-effective network facilities include the following:

- Upgrade Laboratory network facilities to provide high-speed network architectures.
- Reengineer remote-access systems to allow secure use of Internet service providers.
- Upgrade Laboratory networks to provide redundancy and enhanced security.
- Ensure Argonne's interoperability with other DOE sites and commercial service providers through the continued use of test beds based on standards adopted at the Laboratory.
- Support DOE's Information Architecture Initiative by actively participating in DOE standards committees and task groups.

Key strategies for achieving high-quality, cost-effective telephone services include the following:

- Take full advantage of competitive market options beyond 2002 to acquire cost-effective voice, data, and video network services that can be reconfigured quickly if any single carrier fails.
- Encourage carriers to provide voice, data, and video services to the Laboratory via dedicated fiber-optic cable.
- Deploy an internal telecommunications architecture based on standards widely supported by the commercial telephone service providers for their high-speed interconnections, to ensure that the Laboratory

benefits from compatibility and maximum flexibility in meeting future needs.

- Upgrade the Laboratory's central telephone switch in 2002-2003; eventually replace this switch by merging its functions with the advanced network switching technologies now available.

Key strategies for maintaining strong core competencies in current and emerging information technologies include the following:

- Work with the National Energy Research Supercomputer Center and several other national laboratories and agencies to develop cross-realm authentications for the ESnet wide-area network and the emerging next-generation Internet.
- Work with ESnet and several other national laboratories and agencies to ensure Argonne's interoperability with other DOE sites and commercial service providers by means of continued use of test beds based on standards adopted at the Laboratory.
- Participate in a DOE pilot project to demonstrate high-performance network environments linked across dedicated commercial interconnections, in preparation for the advanced fast-packet-switching services that will soon be offered generally via ESnet. (These advanced networking initiatives are particularly important as infrastructure for high-performance computing programs at Argonne and for providing convenient access to user facilities such as the Advanced Photon Source.)

The Laboratory operates a suite of central information systems in the areas of records, finance, personnel, procurement, facilities, scientific and technical information, environmental protection, and employee health and safety. Key strategies for achieving high-quality, cost-effective central information systems include the following:

- Develop central information systems by using an information technology capital investment management process implemented by working groups comprising senior management representatives from both programmatic and operations organizations.

- Evaluate the Laboratory's current strategy of purchasing commercially available applications versus a strategy of building applications on a strong web-based infrastructure and architecture.
- Streamline and automate Laboratory business processes to take full advantage of the capabilities of current information system software and developer tools.
- Pursue new initiatives that will improve Laboratory-wide access to data supporting R&D and operations functions.
- Expand the use of electronic data interchange (EDI) to implement electronic commerce more fully in the Laboratory's business activities.
- Simplify user access to operational and administrative information through expanded use of web interfaces.

2. Scientific and Technical Information

Situation

Scientific and technical information (STI) is both an essential driver and the main product of Argonne's R&D. The Laboratory manages its STI via an integrated suite of programmatic and support activities. Infrastructure that supports effective stewardship of STI throughout its life cycle includes virtual and physical library systems, publishing and presentation services, and records management services.

Through digital, print, and staff resources, Argonne's research library provides efficient, structured access to the full range of global scientific and engineering information needed to undertake R&D. The Argonne Information Management (AIM) System is the key mechanism for delivering library resources to researchers. As a web portal to multidisciplinary information resources and services at Argonne and around the world, the AIM System averages over 16,000 user sessions per month. Over the past five years, customer usage of this system has increased 65%, and the average cost per use has dropped 20%.

Dissemination of results from Argonne's R&D is made more effective by centralized

publishing and presentation support services at both major Argonne sites. These services encompass communications planning, writing, editing, the visual arts, and document production, with award-winning products in all conventional and digital media. Final Laboratory publications are posted to a central Internet site to broaden their availability to the global scientific community.

Argonne's central records management services support the preservation of scientific and business information in accord with federal requirements. Services provided include technical assistance to records originators, a records inventory system, storage and disposal of older records, and records searches.

Goals and Objectives

The goal of STI management at Argonne is to enhance the quality, productivity, and recognition of Laboratory R&D by enabling scientists and engineers to acquire and use relevant information rapidly and to communicate their findings effectively. Supporting objectives are (1) to provide high-performance digital systems and human services that give rapid, easy, continually improving access to STI and (2) to operate STI systems and services cost-effectively.

Strategies

Key strategies for providing high-performance STI systems and services include the following:

- Influence the direction of electronic publishing to the benefit of Argonne and other national laboratories through collaboration with private-sector publishers, other research institutions, and federal agencies, taking advantage of national and international forums, such as the Library Advisory Council of the Institute of Electrical and Electronics Engineers, Inc.
- Integrate industry-leading, standards-based, commercial hardware and software systems, as well as forefront creative practices, into Argonne's communications, library, and records management functions.
- Apply insights from internal customer feedback and external peer reviews to enhance

the quality of Argonne's STI infrastructure and services. One example of external review is entry of publication and presentation products into professional peer competitions, which annually bring substantial numbers of awards to the Laboratory.

- Enhance the STI resources available on the desktops of Argonne researchers through the AIM System. The system's growing virtual library includes electronic journals, scientific databases, reports, standards, specialized search and retrieval tools, and inventories of Argonne-authored publications and Argonne records. In 2002, 61% of the 1,118 journal titles purchased by the research library are available to Argonne staff electronically.
- Increase the global public availability of Argonne-authored technical reports and conference papers via both a Laboratory Internet site and DOE-operated information dissemination systems.

Key strategies for achieving cost-effective systems and services include the following:

- Leverage capabilities developed to acquire, use, and communicate STI to improve management of text-based business information. Current examples are the management of office copier rental programs by central document production groups at both major Argonne sites; the integrated management of scientific and business records; and the inclusion of Laboratory manuals, business correspondence, and forms in the research library's AIM System.
- Operate support organizations at both major Argonne sites to provide the STI systems and services that are most efficient when their management is centralized.
- Match the scope and timeliness of institutional STI services to the needs of Argonne's R&D programs, through collaborative planning and budgeting by programmatic and operations staff and management.
- Purchase library collection materials through cost-saving consortial agreements, such as those negotiated by the DOE laboratories' library consortium; link Argonne staff to external library collections of special value,

notably those of the University of Chicago and other major research libraries in Illinois.

- Apply industry best practices for efficiency in all STI activities.

F. Communications, Outreach, and Community Relations

Situation

To conduct its R&D operations efficiently and effectively, Argonne must have the confidence and support of its stakeholders. The Laboratory's major non-DOE stakeholders include Argonne employees, the research community, local and national news media, the trade press, the broad national public, members of the public living near the two Argonne sites, the educational community, and potential licensees and research partners in industry. Accordingly, the Laboratory takes special care to maintain close, positive relationships with all of these groups and to foster a climate of mutual trust. This effort involves constant attention to two-way communications that are accurate, clear, timely, and credible. An active and growing outreach program seeks to inform Argonne's constituents about the Laboratory's work and to involve them constructively in its activities.

The major elements of Argonne's programs in communications, outreach, and community relations involve the following activities:

- *Employee Communications.* Argonne's weekly employee newsletter, according to a recent survey, is read in its entirety or in part by more than 99% of employees. Employee communications are also well served by site-wide electronic mail broadcasts, a continually updated intranet, a telephone INFO-line, on-site technical and scientific seminars and conferences, colloquia featuring renowned speakers, and a variety of special employee events. An annual highlight is the "State of the Laboratory" address by Argonne's director.
- *The Research Community.* Ongoing communications with peers in the research community are conducted by staff who publish more than 2,000 research papers and

reports annually and who participate in scientific and technical conferences — often presenting papers or sponsoring events.

- *Media Relations.* Argonne's external communications efforts mainly target the news media, which constitute the Laboratory's major avenue for informing the national and local public about both the long-term value of scientific research in general and the benefits of Argonne and DOE-funded research in particular.

- *Trade Press.* The trade press is an important vehicle for informing industrial researchers and executives about Argonne's research and facilities, which can help industry solve its research problems and can lead to other productive relationships, such as R&D partnerships.

- *Community Relations.* Argonne's wide-ranging community relations programs reach all of the Laboratory's major stakeholder groups. These programs include site tours, open houses and other special events, speeches by staff to external audiences, and a vast array of Laboratory-sponsored conferences and seminars.

Communications and outreach are also important aspects of other major Laboratory activities discussed elsewhere in this *Institutional Plan*, notably science education (see Section IV.A.1.j) and technology transfer (see Section IV.A.4 and Supplement 2).

Goals and Strategies

Argonne continually seeks opportunities to further strengthen the Laboratory's programs in communications, outreach, and community relations. Pursuit of the following important opportunities is under way or being planned:

- The Laboratory is increasing its traditional outreach to the general science news media through efforts such as increased representation at press briefings and annual meetings of professional research societies.
- The science content of Argonne's quarterly magazine *logos* is being increased, and the publication is being repositioned to target a

primary audience of researchers and “the interested layperson.”

- The effectiveness of the Laboratory’s Speakers Bureau is being strengthened and rejuvenated through an aggressive outreach program to make potential audiences more aware of Argonne speakers and the relevance of their topics and expertise to the interests of stakeholder groups.
- The Argonne Information Center is being enhanced through the efforts of a new committee that is developing outreach programs aimed at community and educational groups.
- Argonne will continue to work closely with DOE-Chicago Operations and its Argonne Area Office to nurture a series of quarterly meetings with leaders from communities neighboring Argonne-East. This highly successful Community Leaders Roundtable keeps Argonne’s neighbors informed about the Laboratory’s activities and expected impacts to the surrounding area, and it provides an informal forum for feedback.

For more than a half century, Argonne has benefited from remarkably strong community support, positive news media relations, and strong management commitment to communications and outreach. The strategies outlined above are designed to build on those successes.

G. Performance Management

Situation

The performance-based *Prime Contract* under which the University of Chicago operates Argonne for DOE specifies objectives, performance measures, and incentives that foster outstanding performance by the Laboratory. Since FY 1996, the Laboratory’s performance has been evaluated on the basis of previously negotiated measures and expectations, as specified in Appendix B of the *Prime Contract*. (The term of the current contract extends through September 2004.)

Argonne’s performance ratings have consistently been in the range of excellent to outstanding. In FY 2001 Argonne achieved a rating of outstanding in all three major performance categories: Science and Technology, Critical Operations, and General Operations. (See Figure V.5.)

Goals

Performance management begins with identification — by top Argonne management, the University of Chicago, and DOE — of high-level performance goals in three broad areas:

- Science and Technology — Argonne will deliver innovative, forefront science and technology aligned with DOE strategic goals and will conceive, design, construct, and operate world-class user facilities, all in a safe, environmentally sound, efficient manner.
- Contractor Management — The University of Chicago will provide leadership, guidance, and oversight that add value to the overall management of Argonne.
- Operations — Argonne will conduct all work and operate facilities cost-effectively and with distinction to achieve integration with and support of its missions in science, technology, energy, and environment, plus full protection of its workers, users of its facilities, the public, and the environment.

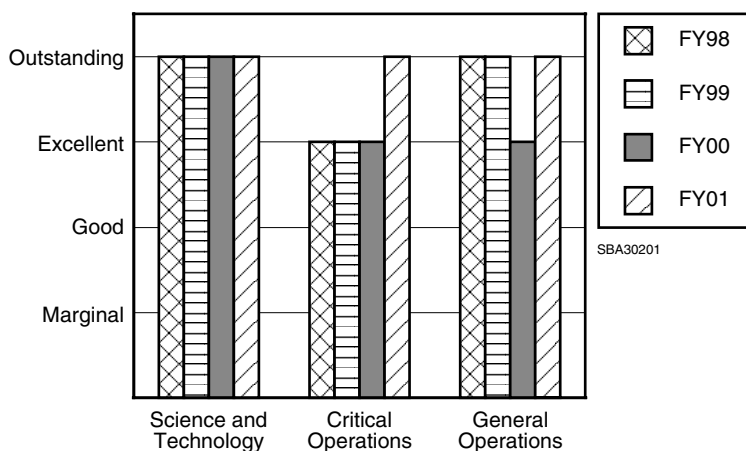


Figure V.5 Argonne Performance Ratings

Strategies

Performance measures are developed for Argonne with the following criteria in mind:

- Contributes directly to or enhances the Laboratory's ability to accomplish its R&D mission.
- Drives performance by concentrating on desired outcomes.
- Compels the Laboratory to focus on systems performance, cost-effectiveness, and continuous improvement of functions and services essential to its mission.
- Allows for meaningful analysis of trends and rates of change.
- Adds commensurate value in the context of the Laboratory's mission and its entire performance plan.

The Critical Operations performance category considers functions that have a direct and significant impact on the Laboratory's ability to carry out its missions. Performance in this area and in Science and Technology determines the annual fee received by the University of Chicago from DOE. In FY 2001 the operational functions in the Critical Operations category were leadership, ISM, project and infrastructure management, and cyber security. Table V.3 gives examples of performance measures in those four functional areas. Figure V.6 indicates the weightings given the four areas.

Table V.3 Critical Operations — Examples of Performance Measures

Functional Area	Measure
Integrated Safety Management	Laboratory air and water effluents compared to U.S. Environmental Protection Agency compliance standards
Project and Infrastructure Management	Actual costs and milestones compared to predetermined schedules
Leadership	Effective succession planning demonstrated for key personnel
Cyber Security	Identified system vulnerabilities addressed on schedule

A number of operational activities not identified as critical are nevertheless included in Argonne's performance management process. Performance in these general operations activities (see Table V.4) does not directly affect the University's performance fee, but it does affect the size of the Laboratory's annual employee bonus pool.

Table V.4 General Operations Functions

Communications and trust	Procurement
Counterintelligence	Property management
Finance	Publishing
Human resources and diversity	Safeguards and security
Information management	Technology transfer
Legal management	Work for others

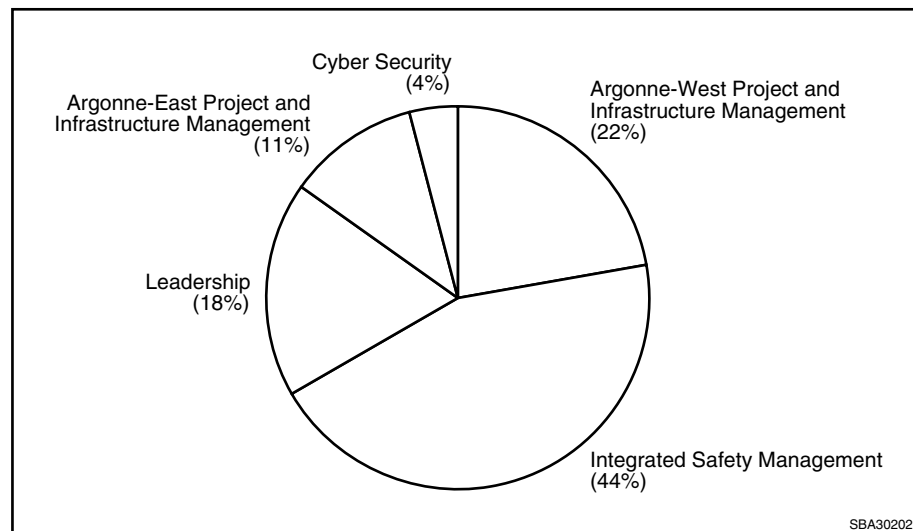


Figure V.6 Critical Functions by Contribution to the FY 2001 Operations Performance Rating

Working together, DOE, the University of Chicago, and Argonne have built strong momentum in continuously enhancing performance through ongoing feedback and improvement across the Laboratory. Ongoing improvement includes refinement of the measures used to drive performance, in order to better reflect desired outcomes and value added to the Laboratory's research programs. As a general

strategy, the university and the Laboratory are seeking to increase the use of peer review in the oversight and management of Laboratory operations.

H. Cost-Effectiveness of Support Functions

As a broad goal, Argonne seeks to achieve productivity improvements sufficient to accommodate a moderate decline in the total constant-dollar resources received by the Laboratory. More specifically, Argonne seeks increased efficiency and effectiveness in its overhead and technical support services sufficient to maintain a stable scientific workforce.

Situation

Argonne's overhead management process has contributed significantly to reducing the Laboratory's overhead rate over the past several years, a time when DOE initiatives exerted great cost pressure. As indicated in Figure V.7, the Laboratory was able to reduce its overhead cost percentage performance metric from 22.4% in FY 1994 to 19.5% in FY 2001. Argonne has maintained an efficient balance of researchers and support personnel, while it has improved the cost-effectiveness of its support functions. Figures V.8-V.10 show further performance metrics indicating

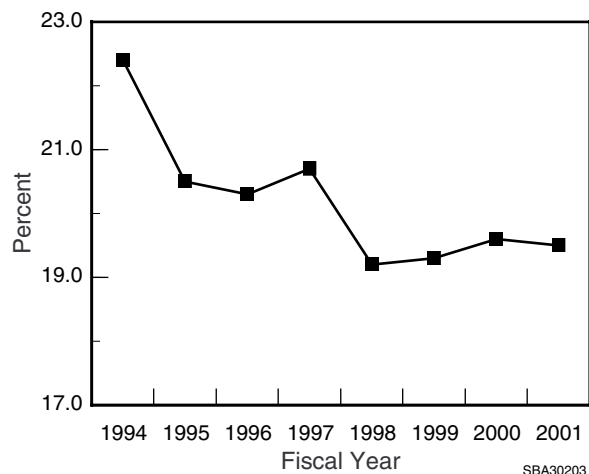


Figure V.7 Overhead Management Performance
(overhead cost as a percent of total operating cost)

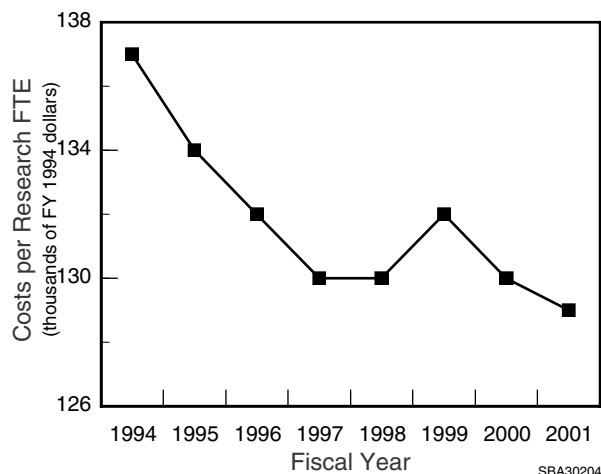


Figure V.8 Operating Costs per Research FTE

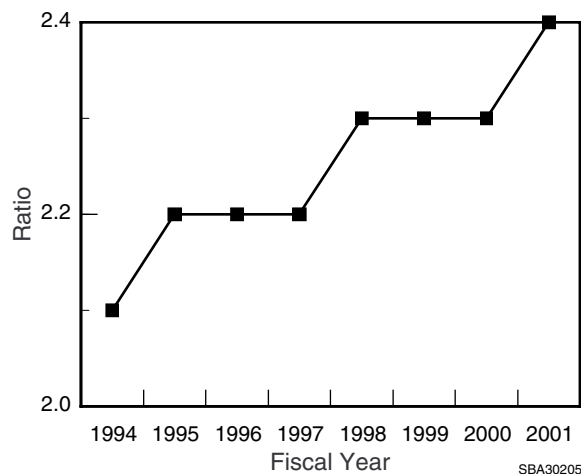


Figure V.9 Research to Support Ratio (research labor costs divided by support labor costs)

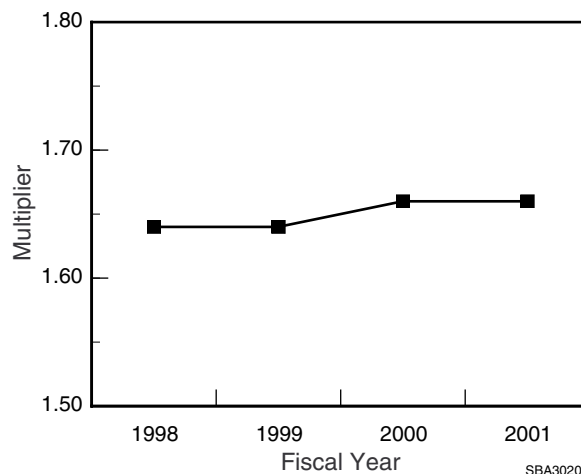


Figure V.10 Composite Support Cost Multiplier on a Direct Research Dollar

the Laboratory's successful commitment to improving efficiency.

Challenges and Strategies

Argonne must continuously improve the productivity of its scientific and support activities and keep its overall cost of operation among the lowest for a DOE multiprogram laboratory. To this end, the Laboratory performs diligent, focused reviews of all its support costs, with particular attention to opportunities for additional process improvements. Reviews of support costs (1) use

thorough, activity-based costing plans and tracking mechanisms to identify high-cost activities; (2) focus on documentation of baseline data and benchmarking of processes; and (3) generally create an atmosphere conducive to results-oriented management. Careful attention is given to identifying more effective cost-distribution methodologies. Argonne seeks out and adopts best practices in other organizations, including private firms and other laboratories. At the same time, best practices within the Laboratory are identified for broader application.

VI. Resource Projections

The resource projections in this chapter are considered a reasonable baseline for planning the desired future of the Laboratory and for addressing important contingencies, particularly those associated with increasingly stringent federal budgets. The projections do not necessarily represent the outcome that the Laboratory considers most likely.

The projections show levels of activity at Laboratory, program, and subprogram levels. The resources required for Argonne's initiatives for years beyond FY 2002 generally are not included in these resource projections. Funds received in FY 2001 and FY 2002 for initiatives are included in the funding levels shown for those years. Only funded and budgeted construction projects are included in the tables.

The figures for FY 2001 represent historical dollar values. The FY 2002 figures are midyear projections in current dollars. Projections beyond FY 2002 incorporate annual cost escalation percentages that have been reviewed by DOE.

The resource projections are presented in 16 tables:

- Tables VI.1 summarizes Laboratory total funding, while Table VI.2 gives total full-time-equivalent (FTE) personnel levels.
- Tables VI.3 and VI.4, respectively, summarize total Laboratory funding and total personnel (FTE) levels for each DOE secretarial office.
- Tables VI.5-VI.16 give operating, capital equipment, and construction funding, along with FTE personnel levels, for each subprogram within specified DOE secretarial offices and for work supported by non-DOE organizations. Tables VI.5-VI.12 describe work funded directly by DOE, Table VI.13 considers work funded by DOE contractors (as well as funds transferred by Argonne to other DOE contractors), and Tables VI.14-VI.16 pertain to work funded by all other organizations.

Table VI.1 Laboratory Funding Summary (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
DOE Funding	408.7	406.4	433.0	490.9	505.9	498.0	496.6
Funds Transferred to Other DOE Contractors	-17.7	-17.0	-18.0	-18.0	-18.0	-18.0	-18.0
Work for Others (WFO) Program	70.6	76.2	71.5	71.2	70.1	67.6	66.7
Additional Work for Non-DOE Organizations	6.1	4.4	7.4	7.8	5.3	5.3	5.3
Total Operating	467.7	470.0	493.9	551.9	563.3	552.9	550.6
Capital Equipment ^a	16.1	13.9	17.9	24.7	21.1	19.3	18.5
Construction ^{a,b}	0.0	4.0	30.0	20.0	0.0	0.0	0.0
General Purpose Equipment	2.0	1.8	2.2	2.2	2.2	2.2	2.2
Accelerator Improvement Projects ^b	4.5	4.3	6.7	0.0	0.0	0.0	0.0
General Plant Projects ^b	9.2	7.9	13.8	0.0	0.0	0.0	0.0
Multiprogram Energy Laboratories — Facilities Support Program ^b	6.1	3.0	2.8	5.2	0.0	0.0	0.0
Total Laboratory Funding	505.6	504.9	567.3	604.0	586.6	574.4	571.3

^aCapital Equipment and Construction can include funding from sources other than DOE. The state of Illinois is projected to fund construction of (1) the Center for Nanoscale Materials building and (2) the Rare Isotope Accelerator Science Center building (see Table VI.15).

^bAs required by DOE instructions, Construction, Accelerator Improvement Projects, General Plant Projects, and Multiprogram Energy Laboratories — Facilities Support Program include only funded and budgeted projects. They do not include proposed projects and, unlike other funding categories, are not intended to represent a reasonable baseline for Laboratory planning in the later years of the planning horizon. (See Table S3.2 for a detailed description of construction projects that have been funded or budgeted by DOE [as included in these resource projections], as well as other projects the Laboratory has proposed to DOE that have not yet been funded or budgeted.)

Table VI.2 Laboratory Personnel Summary (in FTE)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Direct Personnel							
DOE Effort	1924.5	1939	1951	2104	2104	2099	2081
Work for Others (WFO) Program	283.2	284	280	252	244	215	214
Additional Work for Non-DOE Organizations ^a	7.7	7	6	5	5	5	5
Subtotal	2215.4	2230	2237	2361	2353	2319	2300
Other Direct ^b	488.2	501	515	538	536	524	521
Total Direct Personnel	2703.6	2731	2752	2899	2889	2843	2821
Indirect Personnel	1220.8	1250	1265	1290	1290	1290	1290
Total Personnel	3924.4	3981	4017	4189	4179	4133	4111

^aIncludes FTEs associated with services provided to Advanced Photon Source users and work for partners in cooperative R&D agreements.

^bThe "other direct" personnel category includes FTEs for general Laboratory services, program management and administration, staff temporary assignments, and Laboratory Directed Research and Development.

Table VI.3 Funding by Assistant Secretarial Office (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
DOE WORK							
Table VI.5 — Science							
Operating	211.9	209.9	212.1	248.1	251.2	249.8	252.0
Capital Equipment	14.5	13.4	16.4	20.5	20.5	19.3	18.5
General Purpose Equipment	2.0	1.8	2.2	2.2	2.2	2.2	2.2
Accelerator Improvement Projects ^a	4.5	4.3	6.7	0.0	0.0	0.0	0.0
General Plant Projects ^a	9.2	7.4	11.5	0.0	0.0	0.0	0.0
Subtotal	242.1	236.8	248.9	270.8	273.9	271.3	272.7
Multiprogram Energy Laboratories — Facilities Support Program ^a	6.1	3.0	2.8	5.2	0.0	0.0	0.0
Total Science	248.2	239.8	251.7	276.0	273.9	271.3	272.7
Table VI.6 — Nuclear Energy, Science and Technology							
Operating	77.5	75.8	82.0	96.2	100.5	103.9	118.0
General Plant Projects ^a	0.0	0.5	2.3	0.0	0.0	0.0	0.0
Total	77.5	76.3	84.3	96.2	100.5	103.9	118.0
Table VI.7 — Energy Efficiency and Renewable Energy							
Operating	38.1	34.0	37.6	38.2	38.3	38.1	38.1
Capital Equipment	0.3	0.5	1.4	4.1	0.5	0.0	0.0
Total	38.4	34.5	39.0	42.3	38.8	38.1	38.1
Table VI.8 — Fossil Energy							
Operating	4.4	5.5	5.7	5.6	5.6	5.6	5.6
Capital Equipment	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Total	4.4	5.5	5.8	5.7	5.6	5.6	5.6
Table VI.9 — Environmental Management							
Operating	20.8	10.3	17.2	17.4	21.0	25.9	26.2
Capital Equipment	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	20.9	10.3	17.2	17.4	21.0	25.9	26.2
Table VI.10 — National Nuclear Security Administration							
Operating	15.7	17.6	22.5	29.4	29.7	30.4	24.7
Capital Equipment	0.1	0.0	0.0	0.0	0.1	0.0	0.0
Total	15.8	17.6	22.5	29.4	29.8	30.4	24.7

Table VI.3 Funding by Assistant Secretarial Office (Cont.)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Table VI.11 — Security and Emergency Operations							
Operating	1.6	2.2	4.6	4.5	4.5	4.5	4.5
Capital Equipment	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	2.7	2.2	4.6	4.5	4.5	4.5	4.5
Table VI.12 — Other DOE Programs^b							
Operating	3.4	3.1	3.3	3.5	3.5	3.6	3.5
Table VI.13 — Work for Other DOE Contractors							
Operating	35.3	48.0	48.0	48.0	51.6	36.2	24.0
TOTAL WORK FOR DOE PROGRAMS							
Operating	408.7	406.4	433.0	490.9	505.9	498.0	496.6
Capital Equipment	16.1	13.9	17.9	24.7	21.1	19.3	18.5
General Purpose Equipment	2.0	1.8	2.2	2.2	2.2	2.2	2.2
Accelerator Improvement Projects ^a	4.5	4.3	6.7	0.0	0.0	0.0	0.0
General Plant Projects ^a	9.2	7.9	13.8	0.0	0.0	0.0	0.0
Subtotal	440.5	434.3	473.6	517.8	529.2	519.5	517.3
Multiprogram Energy Laboratories — Facilities Support Program ^a	6.1	3.0	2.8	5.2	0.0	0.0	0.0
Total	446.6	437.3	476.4	523.0	529.2	519.5	517.3
Funds Transferred to Other DOE Contractors (Operating)	-17.7	-17.0	-18.0	-18.0	-18.0	-18.0	-18.0
Table VI.14 — Work for Others (WFO) Program							
Operating	70.6	76.2	71.5	71.2	70.1	67.6	66.7
Construction	0.0	4.0	30.0	20.0	0.0	0.0	0.0
Total	70.6	80.2	101.5	91.2	70.1	67.6	66.7
Table VI.15 — Additional Work for Non-DOE Organizations							
Operating	6.1	4.4	7.4	7.8	5.3	5.3	5.3
TOTAL OPERATING FUNDING	467.7	470.0	493.9	551.9	563.3	552.9	550.6

Table VI.3 Funding by Assistant Secretarial Office (Cont.)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
TOTAL CAPITAL EQUIPMENT	16.1	13.9	17.9	24.7	21.1	19.3	18.5
TOTAL CONSTRUCTION	0.0	4.0	30.0	20.0	0.0	0.0	0.0
TOTAL GENERAL PURPOSE EQUIPMENT	2.0	1.8	2.2	2.2	2.2	2.2	2.2
TOTAL ACCELERATOR IMPROVEMENT PROJECTS	4.5	4.3	6.7	0.0	0.0	0.0	0.0
TOTAL GENERAL PLANT PROJECTS	9.2	7.9	13.8	0.0	0.0	0.0	0.0
TOTAL MULTIPROGRAM ENERGY LABORATORIES — FACILITIES SUPPORT PROGRAM	6.1	3.0	2.8	5.2	0.0	0.0	0.0
GRAND TOTAL LABORATORY FUNDING	505.6	504.9	567.3	604.0	586.6	574.4	571.3

^aAs required by DOE instructions, Construction, Accelerator Improvement Projects, General Plant Projects, and Multiprogram Energy Laboratories — Facilities Support Program include only funded and budgeted projects. They do not include proposed projects and, unlike other funding categories, are not intended to represent a reasonable baseline for Laboratory planning in the later years of the planning horizon. (See Table S3.2 for a detailed description of construction projects that have been funded or budgeted by DOE [as included in these resource projections], as well as other projects the Laboratory has proposed to DOE that have not yet been funded or budgeted.)

^bOther DOE programs include B&R codes WN-05, HC, PE, WA-50, CN, TA, and IN. (See Table VI.12.)

Table VI.4 Personnel by Assistant Secretarial Office (in FTE)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
DOE WORK							
Science	1032.6	1072	981	1057	1048	1033	1033
Nuclear Energy, Science and Technology	395.5	406	459	543	569	590	593
Energy Efficiency and Renewable Energy	153.6	143	143	138	135	132	131
Fossil Energy	18.8	30	28	23	23	22	22
Environmental Management	80.5	59	101	94	90	90	90
National Nuclear Security Administration	80.6	77	83	100	96	96	88
Other DOE Programs^a	12.9	15	13	12	12	12	12
Security and Emergency Operations	6.4	11	19	19	18	18	18
Work for Other DOE Contractors	143.6	126	124	118	113	106	94
Work for Others (WFO) Program	283.2	284	280	252	244	215	214
Additional Work for Non-DOE Organizations^b	7.7	7	6	5	5	5	5
SUBTOTAL	2215.4	2230	2237	2361	2353	2319	2300
Other Direct^c	488.2	501	515	538	536	524	521
Total Direct Personnel	2703.6	2731	2752	2899	2889	2843	2821
Indirect Personnel	1220.8	1250	1265	1290	1290	1290	1290
Total Personnel	3924.4	3981	4017	4189	4179	4133	4111

^aIncludes B&R codes WN-05, HC, PE, WA-50, CN, TA, and IN. (See Table VI.12.)

^bIncludes FTEs associated with services provided to Advanced Photon Source users and work for partners in cooperative R&D agreements.

^cThe "other direct" personnel category includes FTEs for general Laboratory services, program management and administration, staff temporary assignments, and Laboratory Directed Research and Development.

Table VI.5 Science: Funding by Subprogram (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Fusion Energy Sciences (AT)							
Operating	2.4	1.7	1.5	1.6	1.8	1.9	2.0
Capital Equipment	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Total	2.4	1.7	1.6	1.7	1.9	2.0	2.1
Safeguards and Security — Science (FS-10)							
Operating	9.6	12.4	7.4	8.7	9.0	9.4	9.7
General Plant Projects ^a	1.4	2.0	1.0	0.0	0.0	0.0	0.0
Total	11.0	14.4	8.4	8.7	9.0	9.4	9.7
Research and Technology (KA-04)							
Operating	8.3	8.3	9.1	10.4	10.7	10.7	10.7
Capital Equipment	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	9.3	8.3	9.1	10.4	10.7	10.7	10.7
High Energy Physics Facilities (KA-05)							
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.6	1.6	1.7	1.9	2.0	2.0	2.0
Total	0.6	1.6	1.7	1.9	2.0	2.0	2.0
Total High Energy Physics (KA)							
Operating	8.3	8.3	9.1	10.4	10.7	10.7	10.7
Capital Equipment	1.6	1.6	1.7	1.9	2.0	2.0	2.0
Total	9.9	9.9	10.8	12.3	12.7	12.7	12.7
Medium Energy Physics (KB-01)							
Operating	3.2	3.3	3.3	3.9	3.9	3.9	3.9
Capital Equipment	0.2	0.1	0.2	0.3	0.3	0.3	0.3
Total	3.4	3.4	3.5	4.2	4.2	4.2	4.2
Nuclear Theory (KB-03)							
Operating	1.1	1.1	1.1	1.7	1.7	1.7	1.7
Low Energy Physics (KB-04)							
Operating	12.0	11.8	13.2	15.8	15.8	15.8	15.8
Capital Equipment	1.0	1.0	1.0	2.2	2.2	2.2	2.2
Accelerator Improvement Projects ^a	0.4	0.4	0.4	0.0	0.0	0.0	0.0
Total	13.4	13.2	14.6	18.0	18.0	18.0	18.0

Table VI.5 Science: Funding by Subprogram (Cont.)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Total Nuclear Physics (KB)							
Operating	16.3	16.2	17.6	21.4	21.4	21.4	21.4
Capital Equipment	1.2	1.1	1.2	2.5	2.5	2.5	2.5
Accelerator Improvement Projects ^a	0.4	0.4	0.4	0.0	0.0	0.0	0.0
Total	17.9	17.7	19.2	23.9	23.9	23.9	23.9
Waste Management (KC-02)							
Operating	7.8	7.8	0.0	0.0	0.0	0.0	0.0
Materials Sciences (KC-02)							
Operating	32.2	32.4	34.4	36.3	38.3	40.0	41.8
Capital Equipment	3.2	3.3	4.6	5.2	5.1	4.2	3.4
Total	35.4	35.7	39.0	41.5	43.4	44.2	45.2
Advanced Photon Source (KC-02)							
Operating	81.2	79.5	81.7	106.6	106.6	106.6	106.6
Capital Equipment	5.5	5.4	5.6	8.4	8.4	8.4	8.4
Accelerator Improvement Projects ^a	4.1	3.9	6.3	0.0	0.0	0.0	0.0
Total	90.8	88.8	93.6	115.0	115.0	115.0	115.0
Total Materials Sciences (KC-02)							
Operating	121.2	119.7	116.1	142.9	144.9	146.6	148.4
Capital Equipment	8.7	8.7	10.2	13.6	13.5	12.6	11.8
Accelerator Improvement Projects ^a	4.1	3.9	6.3	0.0	0.0	0.0	0.0
Total	134.0	132.3	132.6	156.5	158.4	159.2	160.2
Chemical Sciences (KC-03)							
Operating	15.2	14.3	14.3	15.7	16.6	16.6	16.6
Capital Equipment	1.6	1.5	1.5	1.6	1.7	1.7	1.7
General Purpose Equipment	2.0	1.8	2.2	2.2	2.2	2.2	2.2
General Plant Projects ^a	4.8	5.4	10.5	0.0	0.0	0.0	0.0
Total	23.6	23.0	28.5	19.5	20.5	20.5	20.5
Engineering and Geosciences (KC-04)							
Operating	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Capital Equipment	0.4	0.2	0.4	0.4	0.4	0.4	0.4
Total	1.3	1.1	1.3	1.3	1.3	1.3	1.3

Table VI.5 Science: Funding by Subprogram (Cont.)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Total Basic Energy Sciences (KC-02, KC-03, KC-04)							
Operating	137.3	134.9	131.3	159.5	162.4	164.1	165.9
Capital Equipment	10.7	10.4	12.1	15.6	15.6	14.7	13.9
General Purpose Equipment	2.0	1.8	2.2	2.2	2.2	2.2	2.2
Accelerator Improvement Projects ^a	4.1	3.9	6.3	0.0	0.0	0.0	0.0
General Plant Projects ^a	4.8	5.4	10.5	0.0	0.0	0.0	0.0
Total	158.9	156.4	162.4	177.3	180.2	181.0	182.0
Excess Facilities Disposal (KH-01)							
Operating	0.0	0.8	1.0	1.0	0.0	0.0	0.0
Mathematical, Information, and Computational Sciences (KJ-01)							
Operating	11.7	11.1	15.7	16.7	17.0	18.0	18.0
Capital Equipment	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	11.8	11.1	15.7	16.7	17.0	18.0	18.0
Laboratory Technology Research (KJ-02)							
Operating	2.2	0.8	0.2	0.2	0.2	0.2	0.2
Total Computational and Technology Research (KJ)							
Operating	13.9	11.9	15.9	16.9	17.2	18.2	18.2
Capital Equipment	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	14.0	11.9	15.9	16.9	17.2	18.2	18.2
Life Sciences (KP-11)							
Operating	4.6	4.2	4.8	4.6	4.0	0.0	0.0
Capital Equipment	0.3	0.2	1.1	0.3	0.3	0.0	0.0
General Plant Projects ^a	3.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	7.9	4.4	5.9	4.9	4.3	0.0	0.0
Environmental Processes (KP-12)							
Operating	18.4	18.1	21.5	21.6	22.4	22.4	22.4
Capital Equipment	0.6	0.1	0.2	0.1	0.0	0.0	0.0
Total	19.0	18.2	21.7	21.7	22.4	22.4	22.4
Environmental Remediation (KP-13)							
Operating	0.7	0.8	1.2	1.4	1.4	0.8	0.8

Table VI.5 Science: Funding by Subprogram (Cont.)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Medical Applications and Measurement Science (KP-14)							
Operating	0.0	0.2	0.2	0.1	0.0	0.0	0.0
Total Biological and Environmental Research (KP)							
Operating	23.7	23.3	27.7	27.7	27.8	23.2	23.2
Capital Equipment	0.9	0.3	1.3	0.4	0.3	0.0	0.0
General Plant Projects ^a	3.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	27.6	23.6	29.0	28.1	28.1	23.2	23.2
Total Office of Science Program Direction (KX)							
Operating	0.4	0.4	0.6	0.9	0.9	0.9	0.9
Total Science							
Operating	211.9	209.9	212.1	248.1	251.2	249.8	252.0
Capital Equipment	14.5	13.4	16.4	20.5	20.5	19.3	18.5
General Purpose Equipment	2.0	1.8	2.2	2.2	2.2	2.2	2.2
Accelerator Improvement Projects ^a	4.5	4.3	6.7	0.0	0.0	0.0	0.0
General Plant Projects ^a	9.2	7.4	11.5	0.0	0.0	0.0	0.0
Subtotal	242.1	236.8	248.9	270.8	273.9	271.3	272.7
Multiprogram Energy Laboratories — Facilities Support Program ^a	6.1	3.0	2.8	5.2	0.0	0.0	0.0
Total Science	248.2	239.8	251.7	276.0	273.9	271.3	272.7

^aAs required by DOE instructions, Construction, Accelerator Improvement Projects, General Plant Projects, and Multiprogram Energy Laboratories — Facilities Support Program include only funded and budgeted projects. They do not include proposed projects and, unlike other funding categories, are not intended to represent a reasonable baseline for Laboratory planning in the later years of the planning horizon. (See Table S3.2 for a detailed description of construction projects that have been funded or budgeted by DOE [as included in these resource projections], as well as other projects the Laboratory has proposed to DOE that have not yet been funded or budgeted.)

Table VI.6 Nuclear Energy, Science and Technology: Funding by Subprogram (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Nuclear Energy Research and Development (AF)							
Operating	77.5	75.8	82.0	96.2	100.5	103.9	118.0
General Plant Projects ^a	0.0	0.5	2.3	0.0	0.0	0.0	0.0
Total	77.5	76.3	84.3	96.2	100.5	103.9	118.0
Program Direction - Nuclear Energy (KK-05)							
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Nuclear Energy, Science and Technology							
Operating	77.5	75.8	82.0	96.2	100.5	103.9	118.0
General Plant Projects ^a	0.0	0.5	2.3	0.0	0.0	0.0	0.0
Total	77.5	76.3	84.3	96.2	100.5	103.9	118.0

^aAs required by DOE instructions, Construction, Accelerator Improvement Projects, General Plant Projects, and Multiprogram Energy Laboratories — Facilities Support Program include only funded and budgeted projects. They do not include proposed projects and, unlike other funding categories, are not intended to represent a reasonable baseline for Laboratory planning in the later years of the planning horizon. (See Table S3.2 for a detailed description of construction projects that have been funded or budgeted by DOE [as included in these resource projections], as well as other projects the Laboratory has proposed to DOE that have not yet been funded or budgeted.)

Table VI.7 Energy Efficiency and Renewable Energy: Funding by Subprogram (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Solar and Renewable Resource Technologies (EB)							
Operating	4.3	4.1	4.4	4.6	4.6	4.6	4.6
Capital Equipment	0.2	0.3	0.5	0.7	0.0	0.0	0.0
Total	4.5	4.4	4.9	5.3	4.6	4.6	4.6
Building Technology, State and Community Sector (EC)							
Operating	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Industries of the Future (Specific) (ED-18)							
Operating	2.5	1.5	1.5	1.5	1.5	1.5	1.5
Industries of the Future (Crosscutting) (ED-19)							
Operating	0.7	0.1	0.3	0.2	0.2	0.2	0.2
Total Industry Sector (ED)							
Operating	3.2	1.6	1.8	1.7	1.7	1.7	1.7
Vehicle Technologies R&D (EE-05)							
Operating	25.0	23.3	24.6	24.5	24.5	24.5	24.5
Capital Equipment	0.1	0.2	0.9	1.7	0.5	0.0	0.0
Total	25.1	23.5	25.5	26.2	25.0	24.5	24.5
Fuels Utilization R&D (EE-06)							
Operating	1.1	0.4	0.8	0.8	0.8	0.8	0.8
Materials Technologies (EE-07)							
Operating	1.7	1.8	2.9	3.1	3.1	3.1	3.1
Technology Deployment (EE-08)							
Operating	1.1	1.0	1.2	1.7	1.7	1.5	1.5
Capital Equipment	0.0	0.0	0.0	1.7	0.0	0.0	0.0
Total	1.1	1.0	1.2	3.4	1.7	1.5	1.5
Implementation and Program Management (EE-09)							
Operating	0.9	0.9	0.9	0.9	1.0	1.0	1.0

Table VI.7 Energy Efficiency and Renewable Energy: Funding by Subprogram (Cont.)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Total Transportation Sector (EE)							
Operating	29.8	27.4	30.4	31.0	31.1	30.9	30.9
Capital Equipment	0.1	0.2	0.9	3.4	0.5	0.0	0.0
Total	29.9	27.6	31.3	34.4	31.6	30.9	30.9
Policy and Management (EH)							
Operating	0.3	0.2	0.3	0.3	0.3	0.3	0.3
Distributed Energy Resources (EO-01)							
Operating	0.0	0.5	0.5	0.4	0.4	0.4	0.4
In-House Energy Management (WB)							
Operating	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Total Energy Efficiency and Renewable Energy							
Operating	38.1	34.0	37.6	38.2	38.3	38.1	38.1
Capital Equipment	0.3	0.5	1.4	4.1	0.5	0.0	0.0
Total	38.4	34.5	39.0	42.3	38.8	38.1	38.1

Table VI.8 Fossil Energy: Funding by Subprogram (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Coal (AA)							
Operating	3.1	3.6	3.8	4.0	4.0	4.0	4.0
Gas (AB)							
Operating	0.3	0.9	0.9	0.8	0.8	0.8	0.8
Capital Equipment	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Total	0.3	0.9	1.0	0.9	0.8	0.8	0.8
Petroleum (AC)							
Operating	0.8	0.6	0.6	0.4	0.4	0.4	0.4
Gas and Electricity (AU)							
Operating	0.2	0.4	0.4	0.4	0.4	0.4	0.4
Total Fossil Energy							
Operating	4.4	5.5	5.7	5.6	5.6	5.6	5.6
Capital Equipment	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Total	4.4	5.5	5.8	5.7	5.6	5.6	5.6

Table VI.9 Environmental Management: Funding by Subprogram (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Uranium Facilities Maintenance and Remediation (EU)							
Operating	0.2	0.2	0.2	0.2	0.5	0.5	0.5
Environmental Restoration and Waste Management — Defense (EW)							
Operating	9.0	4.7	4.6	8.1	11.0	15.5	15.4
Capital Equipment	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	9.1	4.7	4.6	8.1	11.0	15.5	15.4
Environmental Restoration and Waste Management — Non-Defense (EX)							
Operating	11.6	5.4	5.2	1.5	1.5	1.5	1.5
Safeguards and Security — Environmental Management (FS-30)							
Operating	0.0	0.0	7.2	7.6	8.0	8.4	8.8
Total Environmental Management							
Operating	20.8	10.3	17.2	17.4	21.0	25.9	26.2
Capital Equipment	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	20.9	10.3	17.2	17.4	21.0	25.9	26.2

Table VI.10 National Nuclear Security Administration: Funding by Subprogram (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Weapons Activities (DP)							
Operating	2.3	2.1	1.4	1.0	1.0	1.1	0.9
Capital Equipment	0.1	0.0	0.0	0.0	0.1	0.0	0.0
Total	2.4	2.1	1.4	1.0	1.1	1.1	0.9
Defense Nuclear Nonproliferation (NN)							
Operating	13.4	15.4	21.0	28.3	28.6	29.2	23.7
Program Direction — National Nuclear Security Administration (PS)							
Operating	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Total National Nuclear Security Administration							
Operating	15.7	17.6	22.5	29.4	29.7	30.4	24.7
Capital Equipment	0.1	0.0	0.0	0.0	0.1	0.0	0.0
Total	15.8	17.6	22.5	29.4	29.8	30.4	24.7

Table VI.11 Security and Emergency Operations: Funding by Subprogram (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Nuclear Safeguards and Security (GD)							
Operating	1.6	2.2	4.6	4.5	4.5	4.5	4.5
Capital Equipment	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	2.7	2.2	4.6	4.5	4.5	4.5	4.5
Security and Emergency Operations^a (SO)							
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Security and Emergency Operations							
Operating	1.6	2.2	4.6	4.5	4.5	4.5	4.5
Capital Equipment	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	2.7	2.2	4.6	4.5	4.5	4.5	4.5

^aIncludes estimates for Argonne's safeguards and security program.

Table VI.12 Other DOE Programs: Operating Funding by Assistant Secretary (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Management, Budget, and Evaluation (WN-05)^a	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Environment, Safety, and Health (HC)	0.5	0.5	0.6	0.6	0.6	0.6	0.6
Policy and International Affairs (PE)	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Economic Impact and Diversity (WA-50)	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Counterintelligence (CN)	1.1	1.1	1.1	1.3	1.3	1.4	1.4
Energy Information Administration (TA)	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Intelligence (IN)	0.3	0.3	0.4	0.4	0.4	0.4	0.3
Total Other DOE Programs	3.4	3.1	3.3	3.5	3.5	3.6	3.5

^aRecovery of safeguards and security costs associated with work for sponsors other than DOE.

Table VI.13 Work for Other DOE Contractors (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Operating	35.3	48.0	48.0	48.0	51.6	36.2	24.0
Funds Transferred to Other DOE Contractors	-17.7	-17.0	-18.0	-18.0	-18.0	-18.0	-18.0

Table VI.14 Work for Others (WFO) Program: Operating Funding (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
NUCLEAR REGULATORY COMMISSION	8.2	8.5	8.1	8.1	7.5	6.3	6.3
DEPARTMENT OF DEFENSE							
U.S. Air Force	1.4	1.0	1.0	1.0	1.0	1.0	1.0
The Joint Staff	4.0	1.9	1.9	1.9	1.9	1.9	1.9
U.S. Army	11.2	9.6	9.1	8.6	8.6	8.6	8.6
U.S. Navy	2.1	3.4	3.6	3.6	3.6	3.6	3.6
Defense Threat Reduction Agency	0.0	1.3	1.3	1.3	1.3	1.3	1.3
Defense Advanced Research Projects Agency	2.9	1.5	1.0	1.0	1.0	1.0	1.0
Other Defense	0.7	1.0	1.0	1.0	1.0	1.0	1.0
Total Department of Defense	22.3	19.7	18.9	18.4	18.4	18.4	18.4
OTHER FEDERAL AGENCIES							
Environmental Protection Agency	1.8	0.9	1.1	1.0	1.0	1.0	1.0
Federal Emergency Management Agency	1.7	0.5	0.8	0.8	0.8	0.8	0.8
Department of State (International Atomic Energy Agency)	1.7	2.5	3.1	3.6	3.1	3.6	3.1
Department of Health and Human Services ^a	0.4	4.7	3.5	3.6	3.8	3.8	3.8

Table VI.14 Work for Others (WFO) Program: Operating Funding (Cont.)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Department of Transportation	0.5	2.1	2.1	2.1	2.1	2.1	2.1
Department of Agriculture	6.6	6.1	6.1	6.1	6.1	6.1	6.1
National Science Foundation	0.7	0.0	0.0	0.0	0.0	0.0	0.0
National Aeronautics and Space Administration	1.0	1.7	1.8	1.9	2.0	2.1	2.2
Department of Commerce	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Department of the Interior	1.3	0.5	0.5	0.5	0.5	0.5	0.5
Other Agencies	0.8	0.7	0.2	0.7	0.1	0.6	0.1
Total Other Federal Agencies	16.7	19.7	19.2	20.3	19.5	20.6	19.7
NONFEDERAL ORGANIZATIONS							
Private Firms	10.0	10.5	10.0	9.0	9.0	9.0	9.0
Universities	2.7	4.4	3.9	3.9	3.9	3.0	3.0
University of Chicago Grants^a	6.7	6.7	7.1	7.3	7.6	6.3	6.3
State and Local Governments	2.6	5.5	3.2	3.2	3.2	3.0	3.0
International Organizations and Foreign Countries	1.4	1.2	1.1	1.0	1.0	1.0	1.0
Total Nonfederal Organizations	23.4	28.3	25.3	24.4	24.7	22.3	22.3
TOTAL WORK FOR OTHERS (WFO) PROGRAM	70.6	76.2	71.5	71.2	70.1	67.6	66.7

^aGrants that are funded by the National Institutes of Health are reported as University of Chicago Grants.

Table VI.15 Additional Funding from Non-DOE Organizations^a (\$ in millions BA)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
CRADA Partners	3.0	1.0	2.4	1.3	1.3	1.3	1.3
Services to APS Users	3.1	3.4	5.0	6.5	4.0	4.0	4.0
Illinois State Government Grants^b	0.0	4.0	30.0	20.0	0.0	0.0	0.0
Total Additional Funding from Non-DOE Organizations	6.1	8.4	37.4	27.8	5.3	5.3	5.3

^aCertain work performed by Argonne for non-DOE sponsors is not administered under the Laboratory's Work for Others program and so is considered separately in this table. Included here are (1) funds received from cooperative R&D agreement (CRADA) partners, (2) funds received from collaborative access teams at the APS for services performed, and (3) grants from the state of Illinois.

^bFunding from the state of Illinois for (1) the Center for Nanoscale Materials building and (2) the Rare Isotope Accelerator Science Center building.

Appendix: Argonne in an Integrated DOE Laboratory System

Table A.1 describes some of Argonne's more notable direct collaborations with other DOE laboratories. Brief summary descriptions in the table focus on the way effective collaboration is achieved. Not included are detailed discussions of the value of the research and of which laboratory does which tasks. The table also does not describe the many routine ways in which DOE laboratories cooperate, as when one laboratory simply provides technical services to another on the basis of its special capabilities. Omitted as well are major Argonne R&D collaborations that involve only partners outside the DOE laboratory system, though many of the included collaborations do, as noted, extend outside the system to universities and industrial firms.

Table A.1 Argonne's Direct Collaborations with Other DOE Laboratories and Beyond

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 2002)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
SCIENCE				
<i>Spallation Neutron Source construction project</i> , supported by the DOE Office of Basic Energy Sciences (BES). Design and construct a new accelerator-based facility providing the world's most intense pulsed neutron beams for scientific and industrial R&D. The total project cost of this facility, which is being built at Oak Ridge National Laboratory, is \$1.41 billion.	Brookhaven, Lawrence Berkeley, Oak Ridge, Los Alamos, Jefferson Lab. The neutron user community, including universities and industrial firms, plays a key advisory role.	\$291 million	As a group, advise DOE on program directions through the Basic Energy Sciences Advisory Committee. Jointly recommend particular project elements to DOE. Meet approximately every six weeks for in-depth technical coordination on the entire facility construction project.	A new collaborative approach to designing and constructing a major DOE research facility, intended to be a model for future facilities. Each collaborating laboratory is responsible for integrating a major component — ion source, linac, accumulator ring, target, or instrumentation — into the final facility. In addition to taking advantage of each laboratory's distinctive strengths during construction, the new approach will facilitate the eventual shift at the Oak Ridge site to an operations staff with appropriate skills.
<i>Linac Coherent Light Source (LCLS) Research Collaboration</i> , supported by the BES Division of Materials Sciences — at Argonne through the Advanced Photon Source. The collaboration will conduct R&D preparatory to construction of the LCLS, the first free-electron laser test facility in the hard X-ray spectral range. The ultimate goal is the concept for a fourth-generation light source user facility capable of performance greater by many orders of magnitude than that of today's third-generation sources.	Brookhaven, Lawrence Livermore, Los Alamos, Stanford Linear Accelerator. University of California at Los Angeles.	\$1.5 million	Jointly advise DOE on overall program directions. Coordinate to select complementary research activities, subject to DOE approval. Achieve technical coordination across organizations through a quarterly meeting, plus frequent communication between individual investigators as needed.	The LCLS Research Collaboration will lay the groundwork for future cooperation among DOE laboratories in developing new synchrotron radiation facilities, including eventually the fourth-generation light source.
<i>Isolated and Collective Phenomena in Nanocomposite Magnets</i> , a technical project within the DOE Center of Excellence for the Synthesis and Processing of Advanced Materials, which was established by the BES Division of Materials Sciences, in partnership with the DOE laboratories. The goal is improved materials for permanent magnets through improved understanding of the relationship between microstructure and magnetic properties.	Brookhaven, Lawrence Berkeley, Oak Ridge, Idaho Engineering and Environmental, Los Alamos, Ames Laboratory. Industrial manufacturers of permanent magnets.	Approximately \$3 million for the Center of Excellence for the Synthesis and Processing of Advanced Materials	Coordinate to establish appropriate research areas. Mutually select technical approaches that best exploit and integrate the distinctive capabilities of the laboratory partners. Communicate all useful information quickly. Exchange experimental samples for characterization by techniques available at partner laboratories.	The DOE Center of Excellence for the Synthesis and Processing of Advanced Materials was designed specifically as a distributed organization dedicated to promoting a limited number of coordinated, cooperative, multilaboratory research partnerships related to the synthesis and processing of advanced materials for energy technologies. After a finite life of five years within the center, a project is expected to have an established research agenda and associated collaborations and to become a normal DOE program that does not require such intense nurturing. DOE laboratory coordinators for the center's various projects have major input into long-run directions for the center, along with an industry steering group that also helps to review ongoing projects.

Table A.1 Argonne's Direct Collaborations with Other DOE Laboratories and Beyond (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 2002)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
<i>Microstructural Effects on Mechanics of Materials</i> , a project within the DOE Computational Materials Science Network, established by the BES Division of Materials Sciences, in partnership with the DOE laboratories. Elucidate and improve the mechanical properties of polycrystalline materials through improved understanding of the way dislocations interact with grain boundaries during deformation.	Lawrence Berkeley, Oak Ridge, Pacific Northwest, Lawrence Livermore, Los Alamos, Sandia. National Institute of Standards and Technology. MIT, University of Pennsylvania, University of California at Berkeley, Carnegie-Mellon University.	Approximately \$1.1 million	Coordinate to establish appropriate joint research areas involving large-scale, massively parallel computer simulations. Mutually develop and select computer simulation approaches that best exploit and integrate the distinctive capabilities of the partner laboratories. Share all useful information quickly.	The DOE Computational Materials Science Network was designed specifically as a distributed research organization dedicated to promoting closely coordinated, cooperative multilaboratory projects involving large-scale, massively parallel computer simulations of advanced materials. Multilaboratory collaborations are at the heart of the network's strategy for developing new computational approaches to solving important, technologically relevant materials problems.
<i>Granular Flow and Kinetics</i> , funded under the Center of Excellence for the Synthesis and Processing of Advanced Materials by the BES Division of Materials Sciences. Experimentally and theoretically examine the dynamic behavior (e.g., jamming, mixing, segregation, fluidization) of granular media, a very important category of material used extensively by industries such as pharmaceuticals, agriculture, mining, and construction.	Los Alamos, Sandia. Ames. Five universities.	\$3.0 million	Share facilities and expertise to develop comprehensive, synergistic investigations of a broad range of phenomena in granular media, with various partners bringing special capabilities in simulation and modeling, electrostatic fluidization, novel particle-tracking techniques, laboratory-scale fluidized beds, and granular avalanche analysis. Coordinate for the shorter term by conference call every two weeks, for the longer term at an annual workshop.	The DOE Center of Excellence for the Synthesis and Processing of Advanced Materials aims specifically at implementing collaborations that bring to bear complementary capabilities across the DOE laboratory system, in cooperation with university partners.
<i>Development of high-gradient superconducting accelerating structure technology</i> for high energy physics and fourth-generation light sources, a collaboration stemming from a larger technology development collaboration centered at Germany's Deutsche Elektronen Synchrotron (DESY). Supported by the Office of Science. The two DOE laboratories in Illinois plan to share the infrastructure required to adapt the DESY technology to their respective specialized interests and ultimately to serve other applications across the DOE system.	Fermilab. (Roughly 40 institutions worldwide participate in the large DESY-centered collaboration, including Argonne, Fermilab, and two U.S. universities.)	Argonne participation supported by Laboratory-directed resources at this early stage	Advise DOE jointly on general issues and individually on applications (Fermilab for high energy physics, Argonne for fourth-generation light sources). Meet weekly for scientific and engineering discussions and monthly for longer-term planning of the substantial new infrastructure needed.	The long-run objective is to develop for the entire DOE laboratory system a coordinated capability in superconducting accelerator technology that will rely on collaboration with other DOE laboratories as its standard mode of operation.

Table A.1 Argonne's Direct Collaborations with Other DOE Laboratories and Beyond (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 2002)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
U.S. participation in development of the <i>ATLAS detector for the Large Hadron Collider (LHC)</i> to be built at the CERN laboratory in Switzerland. U.S. participation is funded by DOE's High Energy Physics Division and by the National Science Foundation (NSF). By observing particle collisions at energies seven times greater than previously possible, investigate major physics questions such as the mechanism for electroweak symmetry breaking.	Brookhaven, Lawrence Berkeley. Approximately 25 universities.	\$25 million	With university partners, advise DOE as a group through the ATLAS Executive Committee. Coordinate to develop mutually complementary detector components, subject to DOE approval.	This collaboration is notable for including large numbers of institutional and close individual collaborators (even for high energy physics), provision of sizable funding through both DOE and the National Science Foundation (NSF), and an absolute constraint imposed by Congress on total U.S. funding for ATLAS and a second LHC detector. DOE and NSF coordinate funding and management through an innovative joint oversight group to which the DOE laboratories have input through the two detector collaborations. Two levels of contingency funds cushion the absolute U.S. funding cap.
The <i>MINOS detector</i> for long-baseline neutrino oscillations, supported by DOE's High Energy Physics Division. Located in a mine in Minnesota, the detector will receive neutrinos emitted from Fermilab in Illinois after they have traveled 730 kilometers underground.	Fermilab. Several universities.	\$15 million	Select mutually complementary technical approaches, subject to DOE approval. Coordinate closely on day-to-day research activities, often through an R&D task team with members from the two DOE laboratories and from universities.	Of modest size for high energy physics, this collaboration illustrates the effective functioning of procedures that have been refined over many years as the numbers of participants in detector collaborations have increased.
<i>Collider Detector at Fermilab (CDF)</i> , supported by DOE's High Energy Physics Division. The original high-transverse-momentum detector at the Tevatron collider is used to study particle production and dynamics at the world's highest collider energy, including the production of top and bottom quarks and possibly electroweak symmetry breaking.	Fermilab, Lawrence Berkeley. Several U.S. universities and research groups from Italy and Japan.	Approximately \$10 million	Collaborate in CDF upgrading under overall Fermilab leadership. Share in or undertake individually a broad range of tasks, including design, tooling, and task management, with many participating physicists spending a substantial fraction of their time at Fermilab.	This project pioneered many of the now-accepted operational modes for international detector collaborations involving hundreds of high energy physicists. Distinct project construction and operations organizations, responsible for meeting budgets and schedules, are in creative tension with a collaboration organization focused on physics requirements, detector performance, and analysis and publication of results. Atop the physics collaboration is a governing council of institutional representatives that organizes four or five analysis groups for different areas of physics, within which researchers coordinate (e.g., share analysis techniques and prevent overconcentration on popular topics) and review one another's work. The council decides global questions such as collaboration membership and optimization of running conditions for one investigation rather than another.

Table A.1 Argonne's Direct Collaborations with Other DOE Laboratories and Beyond (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 2002)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
Operation of <i>Gammasphere</i> , supported by DOE's Nuclear Physics Division. The world's most powerful gamma-ray detector for studying the structure of atomic nuclei, Gammasphere has been operated successfully at both Lawrence Berkeley and Argonne. Gammasphere is expected to return to Argonne in FY 2003.	Lawrence Berkeley and other national laboratories.	\$800,000	Within a collaboration of 21 institutions, designed, constructed, and tested the \$23 million Gammasphere. Operate the detector (first at Lawrence Berkeley, then at Argonne, and now back at Berkeley) to take advantage of unique complementary accelerator facilities available at each site. Coordinate closely on the very complicated dismantling, moving, and reassembly. Contribute collaborators to many outside experimental teams using Gammasphere. Advise DOE on future directions through the DOE-NSF Nuclear Science Advisory Committee, joint program advisory committees, and other avenues.	The harmonious, efficient relocation of Gammasphere illustrates one way that national laboratories work together effectively as part of a larger system. A current focus is planning and performing R&D for a next-generation gamma detector for tracking gamma interactions.
Research aimed at developing a <i>rare isotope accelerator facility</i> to provide intense beams of short-lived, unstable (radioactive) nuclei for research in nuclear physics and related fields. To be supported by DOE's Nuclear Physics Division.	Lawrence Berkeley, Oak Ridge, Lawrence Livermore, Los Alamos, Jefferson Lab. Michigan State University.	\$2.8 million	Coordinate concepts for various components of the new accelerator facility. Advise DOE jointly on future directions through the DOE-NSF Nuclear Science Advisory Committee, various program advisory committees, and other avenues. Coordinate among bench scientists each year through a national committee meeting and several less formal meetings.	A formal national committee of the collaborative partners advises DOE in detail regarding resource allocation.
<i>Advanced collaboration and software components technology research</i> , supported by the Mathematical, Information, and Computational Sciences Division. Design new mechanisms, interfaces, and modules that enable flexible interoperability of tool kits, codes, and advanced computing resources for mission-critical DOE problems.	Various projects involve Lawrence Berkeley, Oak Ridge, Lawrence Livermore, Los Alamos, and Sandia. University of Southern California. Aerospace Corp.	\$950,000 (for Argonne only)	As a group, advise DOE on long-run program directions.	Various elements of these projects — such as developing interfaces between computational tool kits originating at different laboratories, exploring component-based approaches to large-scale optimization, using numerical kernels to enable code reuse, and creating functionality to support experiments in networked computing — clearly will facilitate future collaboration across DOE sites.
<i>Fusion Energy Sciences</i> . Acquire the knowledge base needed for an economically and environmentally attractive fusion energy source.	Oak Ridge, Pacific Northwest, Sandia. Princeton Plasma Physics Laboratory. University of Illinois, University of Wisconsin, University of California at Los Angeles, University of California at San Diego. General Atomics.	Approximately \$250 million	Advise DOE on long-run program directions via steering committees. Selectively propose projects jointly to DOE. Coordinate with one another and with university and industrial partners through telephone conferences every week or two and through major annual meetings.	The Virtual Laboratory for Technology within the fusion community facilitates the coordination and review of programs. Video conferencing to replace formal meetings is being developed.

Table A.1 Argonne's Direct Collaborations with Other DOE Laboratories and Beyond (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 2002)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
<i>Atmospheric Radiation Measurement (ARM) Program</i> , supported by DOE's Environmental Sciences Division. In order to better understand global and regional climate change, teams of scientists gather field measurements at several diverse sites around the world and develop models of the processes that control solar and thermal infrared radiative transfer in the atmosphere.	Brookhaven, Lawrence Berkeley, Oak Ridge, Pacific Northwest, Lawrence Livermore, Los Alamos, Sandia. National Renewable Energy Laboratory. Also 7 other government organizations, 5 private companies, 12 international organizations, 20 universities.	\$40 million	Participate in science team research, including collaborations with researchers from many organizations. Beyond science team projects selected by formal peer review, advise DOE jointly on program directions through the ARM Management Team. Collaborate daily with other scientists on various functional teams and in various site management offices. Coordinate the participation of other R&D partners, especially in connection with field observations and the analysis of collaborative experiments.	A remarkably diverse collaboration, in terms of geographic dispersion, as well as numbers and types of organizations. The collaboration is pursuing methods of data management and information exchange via the Internet that will facilitate future interlaboratory integration.
<i>Atmospheric Chemistry Program</i> , supported by the Environmental Sciences Division. Advance information about the atmospheric environment, especially regional and continental chemistry and the fate of tropospheric trace chemicals related to energy production; conduct laboratory studies, theoretical investigations, numerical modeling, and collaborative field campaigns.	Brookhaven, Lawrence Berkeley, Pacific Northwest, Lawrence Livermore. One other federal agency, 12 universities.	\$6.5 million	Participate in various projects selected by peer review and closely coordinate their execution, especially through one to four collaborative field experimental campaigns conducted each year. Advise DOE jointly or individually. Meet within special-interest groups of program participants two or three times each year.	Joint fieldwork features use of the Battelle G-1 research aircraft. The program's web site, in addition to research project descriptions, will provide data sets and codes for numerical atmospheric models.
<i>Water Cycle Pilot Study and Initiative</i> , supported by the Environmental Sciences Division. Demonstrate the feasibility of evaluating the components of the hydrologic water cycle by using field observations (at the Walnut River Watershed in Kansas), application of techniques such as analysis of oxygen and hydrogen isotopes in water, and development of atmospheric and belowground hydrologic models.	Brookhaven, Lawrence Berkeley, Oak Ridge, Los Alamos. University partners are anticipated.	\$1.5 million (for the pilot study only)	Advise DOE jointly but informally. Coordinate to select mutually complementary projects, subject to DOE approval. Hold formal meetings annually, informal technical coordination meetings approximately quarterly, and teleconferences as needed. Often collaborate daily, for example in fieldwork.	Interlaboratory collaboration will be particularly close where field measurements serve the common research needs of multiple partners. A framework will be developed by the partners for integrating numerical modeling.

Table A.1 Argonne's Direct Collaborations with Other DOE Laboratories and Beyond (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 2002)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
<i>Center for Research on Carbon Sequestration in Terrestrial Ecosystems (CSiTE)</i> , supported by DOE's Environmental Sciences Division. Perform fundamental research that will lead to acceptable methods for enhancing carbon sequestration in terrestrial ecosystems as one component of a carbon management strategy. Develop (1) scientific understanding of carbon capture and sequestration mechanisms in terrestrial ecosystems across multiple scales, from the molecular to the landscape; (2) conceptual and simulation models for extrapolating understanding of processes across spatial and temporal scales; (3) estimates of the national potential for carbon sequestration; and (4) assessments of environmental and economic impacts from sequestration.	Oak Ridge, Pacific Northwest. Six universities, one international research institute, and four research organizations within the U.S. Department of Agriculture.	Approximately \$2 million	Participate in science team research tasks, including collaboration across institutions. Coordinate administrative and budgetary direction. Through a principal scientist at each national laboratory, provide scientific direction and coordination. Informally advise DOE, jointly or individually. Hold formal coordination or review meetings annually, informal meetings and conference calls more frequently. Collaborate with individual researchers and small groups most often, especially at field sites and in modeling efforts.	CSiTE studies are conducted at multiple scales at common sites. Special sessions at joint meetings are forums for dissemination of information and planning for integrative papers for general-interest scientific journals. The national laboratories and other research partners are planning workshops to examine the feasibility and consequences of various carbon sequestration scenarios, as well as to help focus future research.
NUCLEAR ENERGY, SCIENCE AND TECHNOLOGY				
<i>Nuclear Reactor Technology Lead Laboratories</i> , supported by the Office of Nuclear Energy, Science and Technology. Prepare a technology road map to guide development of next-generation (Generation IV) nuclear energy systems; maintain the staff, facilities, and knowledge base required for future U.S. R&D on advanced nuclear reactors.	Idaho Engineering and Environmental (primary partner); Brookhaven, Oak Ridge, Pacific Northwest, Lawrence Livermore, Los Alamos, and Sandia (participants in development of the Generation IV technology road map).	\$4 million	Advise DOE jointly on the full range of R&D needed to support the future of civilian nuclear power. Hold joint in-depth technical coordination meetings at least once a week. Undertake less formal technical coordination more frequently, often daily.	The two primary partners jointly evaluate new reactor technologies. They organize and host a wide variety of meetings on technical issues, including international forums.
ENERGY EFFICIENCY AND RENEWABLE ENERGY				
<i>High-Temperature Superconducting (HTS) Wire Development</i> , three coordinated cooperative R&D agreements supported by the Office of Electric Energy Systems and Storage. Development and fabrication of novel HTS conductors for electric power systems.	Los Alamos. University of Wisconsin at Madison. American Superconductor.	\$500,000 (for the DOE laboratories only)	Advise DOE jointly regarding long-run program directions through the Wire Development Group, a formally constituted advisory body with broader responsibilities that meets every four months. Coordinate to select complementary research projects and responsibilities, under the leadership of American Superconductor and subject to DOE approval. Use monthly teleconferences and numerous intervening communications among researchers for immediate technical coordination.	Synergy among the DOE laboratories most often involves preparation, characterization, and testing of HTS samples at multiple locations. The Wire Development Group has effectively fostered other important DOE interlaboratory collaborations. In 2000 it received the Collaboration Success Award from the Council for Chemical Research.

Table A.1 Argonne's Direct Collaborations with Other DOE Laboratories and Beyond (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 2002)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
<i>"Industries of the Future"</i> structuring of the Office of Industrial Technologies. A strategy for coordinating and facilitating R&D for energy-intensive materials and process industries, often through partnerships involving DOE laboratories.	All eight other DOE multiprogram national laboratories. National Renewable Energy Laboratory, Ames Laboratory, Federal Energy Technology Center, Savannah River Site, Y-12 Plant, Albany Research Center. Industry trade associations, professional societies, universities, other government agencies, and many industrial firms.	\$149 million	Through the Laboratory Coordinating Council, meet and confer with industry and other potential partners, as well as with the DOE program office. Contribute to the industry-led, DOE-fostered process of creating R&D visions and road maps for seven major industry groups. Create broad R&D partnerships featuring industry cost sharing and often involving multiple DOE laboratories.	The Laboratory Coordinating Council is an important organizational innovation for developing exceptionally broad R&D partnerships between industry and the DOE laboratories, and beyond.
The <i>Advanced Technology Development program on advanced batteries for hybrid vehicles</i> , supported by the Office of Advanced Automotive Technologies. Develop high-power lithium-ion batteries, including the required new materials, processes, and diagnostic techniques.	Brookhaven, Lawrence Berkeley, Idaho Engineering and Environmental, Sandia. Army Research Laboratory. Three universities. Six corporations.	\$7 million	Advise DOE jointly on critical technical barriers to battery development and on long-term R&D needs. Coordinate to select areas of responsibility and complementary research projects, subject to DOE approval. Share results via quarterly two-day coordination meetings, monthly highlight reports, and postings on linked web sites.	Collaboration among laboratories is being facilitated by the development of standardized procedures for battery testing and reporting of results.
ENVIRONMENTAL MANAGEMENT				
Three projects for the <i>Environmental Management Science Program (EMSP)</i> , which is jointly sponsored by the Office of Environmental Management and the Office of Science. Basic research aimed at much better technical solutions to DOE's environmental cleanup problems.	Pacific Northwest. Savannah River Site. Several universities.	\$0.5 million for the projects involving Argonne	Provide broad advice to EMSP (and other Environmental Management programs) through the Strategic Laboratory Council, which includes one representative from each DOE laboratory and facilitates information exchange across institutions, as well as assisting EMSP in other ways, such as organizing joint conferences and workshops. Among R&D partner bench scientists, coordinate once or twice a month.	EMSP is a premier case of integration across sponsoring offices at DOE. Extensive collaboration among EMSP R&D partners is a core strategy, is explicitly encouraged by the program's proposal process, and is increasingly being implemented. An information network exploiting the Internet and other tools helps EMSP researchers communicate and collaborate beyond the program, with technology developers, managers of sites with environmental problems, regulators, and others. National workshops are held with potential DOE users of EMSP technologies.

Table A.1 Argonne's Direct Collaborations with Other DOE Laboratories and Beyond (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 2002)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
<i>Environmental Management programs</i> (other than EMSP, described above). Environmental restoration, waste management, and associated technology development (including R&D, demonstration, testing, and evaluation projects) for DOE sites.	The multiprogram national laboratories. Ames Laboratory, Environmental Measurements Laboratory, Rocky Flats Environmental Technology Site, Savannah River Site. Many industrial firms and universities.	Approximately \$7 million for Argonne alone, including R&D, technical support activities, and actual cleanup	Often advise DOE jointly on appropriate technical approaches, though the majority of R&D projects are selected by a straightforward process of proposals from individual laboratories. Through the Strategic Laboratory Council (as described above for EMSP), advise DOE on long-run R&D directions, program reviews and improvements, and strategic planning, including road maps. Among R&D partner bench scientists, coordinate weekly to monthly.	Technology demonstration projects are often very large in scale and accomplish major programmatic objectives in themselves. The demonstrations give an unusually wide range of technology providers and other collaborators the opportunity to prove themselves.
<i>TechCon program</i> , Office of Science and Technology. Provide technical assistance to private-sector waste management and environmental restoration project teams at DOE sites, for example by encouraging integration of commercial capabilities with emerging technologies.	Pacific Northwest. (Sandia coordinates the Innovative Treatment Remediation Demonstration program, which increasingly cooperates with TechCon.)	Approximately \$0.5 million	Collaborate with DOE, site management private contractors, and subcontractors to identify opportunities to deploy superior remediation technologies to increase performance and reduce cleanup costs. Facilitate interactions among all parties, including stakeholders, helping to identify technology gaps and R&D needs.	TechCon employs (1) forums for multiple-site project vendors and (2) Internet project data gathering and interactions to reduce barriers to the implementation of innovative technologies, thereby achieving waste minimization, cost savings, performance improvement, and risk reduction. This unique mechanism assures integrated use of the best available environmental technologies for DOE site cleanups.
DEFENSE PROGRAMS				
<i>Nuclear Criticality Safety Program</i> , supported by Defense Programs, Environmental Management, and other DOE offices. Establish within DOE an improved and integrated capability to predict criticality in nuclear fission systems through new experiments, benchmarking against available U.S. and international data, refinement of three alternative Monte Carlo computer models used within DOE, and processing of nuclear data into standard working forms.	Oak Ridge, Idaho Engineering and Environmental, Lawrence Livermore, Los Alamos. Two universities.	Approximately \$9 million	As a group, advise DOE on long-run program directions. Work together on tasks such as evaluation of nuclear data, coordinating informally at the bench scientist level approximately every two months. Coordinate quarterly and annually to choose mutually complementary projects, subject to DOE approval.	Resulting information and software will be distributed in standardized form by the DOE-wide code center and will be used easily by engineers throughout DOE and beyond. For example, the refined nuclear criticality computer codes will be incorporated easily into the various laboratories' existing software systems.

Table A.1 Argonne's Direct Collaborations with Other DOE Laboratories and Beyond (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 2002)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
<i>Message-passing interface component of the Software PathForward Program</i> , supported by the Office of Defense Programs through the Accelerated Strategic Computing Initiative. Conduct research needed for implementation of the message-passing interfaces MPI-1 and MPI-2 on high-performance computers; develop new interfaces to exploit advanced networking, enable thread safety, improve input-output performance, and display multigigabyte log files.	Lawrence Livermore, Los Alamos, Sandia. Four software development firms.	\$400,000 (for Argonne only)	To guide implementation of the standards, coordinate through formal meetings twice a year and less formal exchanges about once a month.	One project goal is development of a common message-passing interface standard for use on the high-performance computers of all DOE-Defense Programs laboratories and their research partners.
<i>Scientific Discovery through Advanced Computing (SciDAC)</i> , supported by the Mathematical, Information, and Computational Sciences Division. Create a new generation of software and tools that will enable scientists to exploit terascale computers fully by undertaking projects including (1) development of mathematical and computing systems software to support scientific simulation and (2) collaborative projects and middleware development to support collaboration using distributed resources.	Brookhaven, Lawrence Berkeley, Oak Ridge, Pacific Northwest, Lawrence Livermore, Los Alamos, Sandia. Fermilab, Jefferson Lab, Ames. General Atomics.	\$6.2 million (for Argonne only)	Advise DOE as a group. Coordinate to select projects, subject to DOE approval. Coordinate regularly (though generally not day to day) on important issues such as reviewing authorization policies and protocols, testing new audio and visual technologies, developing consistent interfaces among software libraries, and analyzing problems experienced in transferring petabyte-scale data sets.	Coordination among SciDAC projects extensively uses the Access Grid, an ensemble of advanced resources for facilitating grid-based group-to-group (as opposed to desktop-to-desktop) communication. Feedback from this early use helps improve the Access Grid for a broad range of applications beyond research collaboration, including large-scale distributed meetings and distance education.
DEFENSE NUCLEAR NONPROLIFERATION				
<i>International Nuclear Safety Program</i> (not including the research-oriented International Nuclear Safety Center, discussed below). In cooperation with other Western industrialized countries and international agencies, conduct joint projects with nine former Soviet bloc countries hosting Soviet-designed nuclear reactors to help identify and correct major reactor safety deficiencies and establish a self-sustaining nuclear safety infrastructure.	Brookhaven, Pacific Northwest, Oak Ridge, Idaho Engineering and Environmental. Many U.S. engineering services and other companies.	\$20 million	Coordinate and, within particular projects, participate either individually or as teams. Daily communication is typical among participating laboratories.	Special initiatives focus on reducing risks at the first generation of Soviet-designed reactors. Participation in projects goes beyond other DOE-sponsored research organizations to include the host country (Russia, Ukraine, Armenia, Bulgaria, Czech Republic, Hungary, Lithuania, Slovakia, or Kazakhstan). DOE laboratory collaborators make extensive use of technologies such as videoconferencing and the paperless office.

Table A.1 Argonne's Direct Collaborations with Other DOE Laboratories and Beyond (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 2002)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
<i>International Nuclear Safety Center (INSC).</i> For nuclear power engineering worldwide, promote the open exchange of safety information, cooperate in the development of safer technologies, and help collect and disseminate relevant information (particularly through a remotely accessible electronic database covering engineering information and results from safety analyses for U.S.-designed and Soviet-designed power plants and other nuclear facilities around the world).	Oak Ridge, Pacific Northwest, Idaho Engineering and Environmental. Other INSCs in Russia, Armenia, Lithuania, Kazakhstan, and Ukraine — and, through them, many additional research institutes.	\$0.6 million	Coordinate with experts in other participating countries to establish joint nuclear safety research projects.	The U.S. INSC database and its counterparts at other INSCs include project results that are immediately accessible worldwide via the Internet. These online resources are very valuable in collaborations between countries.
<i>Interior infrastructure preparedness component of the Chemical-Biological Nonproliferation Program,</i> supported by the Office of Research and Development. Develop advanced technologies and technical services to help cities detect and counter the use of chemical or biological weapons by terrorists in subways, airports, high-threat buildings, and other places.	Lawrence Livermore, Los Alamos, Sandia. As this new program develops, partners will include engineering firms and emergency response organizations at all levels of government.	\$1.9 million for the national laboratories	Advise DOE jointly on program directions, both informally and through a formal advisory group. Coordinate to choose mutually complementary projects, subject to approval by the DOE sponsor. Conduct joint R&D on topics such as simulating the impacts of chemical and biological releases.	Effective development and implementation of new technologies to address this complicated problem — such as detectors and computer models for predicting the transport and fate of chemical or biological agents — typically will require integration of expertise from multiple DOE laboratories and industry, plus close cooperation with city governments. Local transit authorities will cooperate in the program as appropriate and will support their own preparedness operations.
<i>Initiatives for Proliferation Prevention,</i> supported by the Office of Nonproliferation and International Security. Identify and develop commercial nonmilitary work for scientists and engineers involved in weapons programs (nuclear, chemical, and biological) in the former Soviet Union (FSU), particularly by involvement of U.S. companies in cooperative R&D through DOE laboratories and ultimately in commercial deployment of FSU technologies.	All eight other DOE multiprogram laboratories. National Renewable Energy Laboratory, Kansas City Plant.	\$34 million	Through the Interlaboratory Advisory Board, advise DOE on long-run program directions, recommend desirable projects to DOE, and oversee the participation of U.S. businesses. Coordinate formally on technical issues every six months, less formally approximately weekly. Use a Lotus Notes database on the Internet to facilitate interlaboratory communication and informal program auditing by DOE.	Before involvement of U.S. companies, an R&D collaboration between a DOE laboratory and one or more FSU institutes is an opportunity to begin the education of FSU participants in intellectual property rights, entrepreneurship, and commercialization. To facilitate the collaborations, DOE has simplified project review processes and fostered implementation of uniform administrative procedures.
<i>Nuclear Cities Initiative,</i> supported by the Office of Nonproliferation and International Security. Identify and initiate commercial business opportunities that will employ former nuclear weapons workers in "closed" Russian cities, in order to help downsize the Russian nuclear weapons complex.	Lawrence Livermore, Los Alamos, Oak Ridge, Pacific Northwest, Sandia. (Initial negotiations have included many small businesses, as well as large companies such as Schlumberger and Motorola.)	\$22 million (mostly passing through to Russian participants)	Advise DOE informally prior to project selection by DOE and project approval by the Russian Ministry of Atomic Energy (Minatom). Coordinate among laboratories through conference calls every two weeks and meetings twice a year.	Activities at each Russian city are coordinated by a lead DOE laboratory.

Table A.1 Argonne's Direct Collaborations with Other DOE Laboratories and Beyond (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 2002)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
<i>Programs of Cooperation on Nuclear Material Protection, Control, and Accounting (MPC&A)</i> between the United States and the successor states of the FSU, supported by the Office of International Material Protection and Emergency Cooperation and the Office of Arms Control and Nonproliferation. Cooperate with Russia and the independent states that process weapons-usable nuclear materials to strengthen site security and help develop MPC&A systems.	Brookhaven, Oak Ridge, Pacific Northwest, Lawrence Livermore, Los Alamos, Sandia. Nonproliferation and National Security Institute, New Brunswick Laboratory, Pantex, Savannah River Site.	\$275 million (plus substantial carryover from FY 2001)	Through the MPC&A Advisory Panel, provide technical recommendations to DOE on program plans and on project scopes, staffings, and budgets. Participate on multilaboratory teams undertaking particular projects, typically coordinating on technical issues at least weekly with team members at other laboratories. Coordinate the participation of other organizations, including FSU research institutes and private companies.	A typical large MPC&A project involves a very diverse set of tasks, to which several DOE laboratories logically contribute on the basis of their established special capabilities. Final implementation is in Russia or the independent states.
<i>BN-350 Shutdown Project</i> , a project of the National Nuclear Security Agency (NNSA) Office of International Safety and Cooperation. Ensure irreversible shutdown of the breeder reactor in Aktau, Kazakhstan, in cooperation with local research organizations, regulators, and other authorities.	Pacific Northwest, Brookhaven. Department of State Nonproliferation and Disarmament Fund (NDF), Nuclear Regulatory Commission, International Science and Technology Center (ISTC).	\$23 million (including NDF and ISTC funds)	Advise DOE jointly, as a group. Work toward harmonization of the tasks led by each laboratory. Provide technology, designs, and equipment in each laboratory's area of expertise. By electronic mail and telephone, coordinate daily on technical issues with partners at the other laboratories and in Kazakhstan.	The methods of communication used between technical experts in Kazakhstan and the United States are routine but effective, in part because similar backgrounds and interests foster a productive rapport.
<i>International Cooperation on Nuclear Export Controls</i> , supported by the Office of Export Control Policy and Cooperation. Help the FSU and other partner countries implement or improve effective systems for controlling the transfer of materials, equipment, and technology that could be used to produce nuclear weapons.	Oak Ridge, Lawrence Livermore, Los Alamos.	Approximately \$3.0 million	As a group, make recommendations to NNSA on long-run program directions and particular projects to be undertaken. Coordinate the participation of technical institutes in the partner countries.	The program is implemented largely through cooperative agreements directly between DOE laboratories and nine technical institutes in the partner states. These arrangements have greatly facilitated identification and training of the technical experts needed by the government agencies administering nuclear export controls.
<i>Highly Enriched Uranium Transparency Implementation Program</i> , supported by the Office of Nonproliferation and National Security. In Russia, monitor the blending down of highly enriched uranium from dismantled nuclear weapons to produce low-enrichment uranium for use in commercial reactors.	Brookhaven, Oak Ridge, Pacific Northwest, Lawrence Livermore, Los Alamos, Sandia. DOE Remote Sensing Laboratory.	\$14.0 million	Advise DOE regarding long-run program directions, both individually and jointly. Hold a formal joint meeting annually; coordinate among researchers typically once a month.	In the future, close interlaboratory coordination and technical collaboration are likely to be required for tasks such as development and implementation of new monitoring technologies.
<i>The joint U.S.-Russian Materials Disposition Program</i> , sponsored by the Office of Fissile Materials Disposition. Convert excess weapons plutonium into spent reactor fuel that is unsuitable for reuse in nuclear weapons.	Oak Ridge, Lawrence Livermore, Los Alamos. Russian research institutes.	\$9 million for the DOE laboratories	Advise DOE about long-run program directions, jointly as a group but informally. Make joint recommendations on projects to NNSA, which makes the final selection.	To coordinate Russian contributions to evaluating the use of fast reactors for plutonium disposition, joint teams with members from Oak Ridge and Argonne visit the Russian research institutes.

Supplement 1: Work for Sponsors other than DOE

Part of Argonne's work is supported by sponsors other than DOE. Major sponsors include the Nuclear Regulatory Commission, Department of Defense, Environmental Protection Agency, Federal Emergency Management Agency, Department of State, National Institutes of Health, Department of Transportation, Department of Agriculture, National Science Foundation, National Aeronautics and Space Administration, Electric Power Research Institute, private firms, universities, and state governments. (See Chapter VI for program funding.)

Argonne's work for non-DOE sponsors supports accomplishment of its mission (see Chapter II) and development of its initiatives (see Chapter III). From a national perspective, this "work for others" (WFO) allows Argonne's unique facilities and capabilities to be applied to national security needs and other U.S. R&D priorities.

The Laboratory's WFO strengthens resources available for DOE missions and programs and promotes development of specific energy and environmental technologies. Furthermore, this WFO enhances Argonne's research capabilities, helps support the infrastructure at the Laboratory, and ultimately increases opportunities to transfer Argonne technologies to productive applications in the private sector. The Laboratory does not undertake work for non-DOE sponsors if that work can be performed satisfactorily by private organizations.

A. Nuclear Regulatory Commission

Argonne conducts research for the Nuclear Regulatory Commission (NRC) under a legislatively mandated memorandum of understanding between DOE and the NRC. Most of the Laboratory's work for the NRC has for many years involved supporting the Office of Nuclear Regulatory Research in its development of rules regarding plant safety and the condition of

physical components. The largest efforts have addressed materials issues, steam generator tubing degradation, high-burnup fuel, and severe-accident behavior. Recently Argonne also began to (1) enhance environmental pathway models for analyzing the transport of residual radioactive contaminants, (2) develop parameters suitable for implementing NRC rules designed to assure public health and safety at nuclear facilities during the termination of licensed operations, and (3) prepare portions of supplemental environmental impact statements for the renewal of reactor operating licenses. In addition, Argonne provides technical assistance to the Office of Nuclear Reactor Regulation and to the Office of Nuclear Materials Safety and Safeguards.

Both the research and the technical assistance performed for the NRC take advantage of the Laboratory's hot cells and its special capabilities in nuclear reactor technology, technical evaluation, systems analysis, materials science, computer code development, environmental risk modeling, and assessment of environmental and health impacts. Argonne's work helps to ensure that U.S. nuclear power plants will continue their safe and efficient production of electricity without emission of carbon dioxide.

1. Office of Nuclear Regulatory Research

Argonne's materials research focuses on the degradation of structural materials in light-water reactors caused by reactor environments, including the effects of water chemistry and neutron irradiation. These studies include measurements of (1) growth rates of stress corrosion cracks in irradiated and nonirradiated materials and (2) the fatigue life of stainless and ferritic steels used in the reactor core, piping, and pressure vessel. Results from these studies are used by the NRC to ensure the structural integrity of plants as they age. The testing includes specimens from operating commercial reactors. Additional irradiation of stainless steels performed in the Halden

test reactor in Norway and the BOR-60 reactor in Russia provides further systematic data on relationships between material composition and susceptibility to cracking after irradiation.

A comprehensive study of degradation in the steam generator tubing of nuclear power plants is under way. Critical areas being addressed include (1) evaluation of techniques used for in-service inspection of steam generator tubes and recommendations for improving the reliability and accuracy of those inspections, (2) validation and improvement of correlations and models for predicting degradation in aging tubes during operations, and (3) investigation of the potential for environmental degradation of Alloy 690, which has been used in most replacement generators in the United States. The studies focus on mill-annealed Alloy 600 tubing, but tests will also be performed on replacement materials such as thermally treated Alloy 600 and Alloy 690.

Argonne is investigating the behavior of high-burnup nuclear fuels for the NRC. To reduce operating costs and minimize the accumulation of spent fuel, nuclear utilities are striving to increase the burnup of their nuclear fuels, thus extracting more electricity from a given amount of fuel and reducing the volume of the spent fuel requiring subsequent handling, the number of refueling outages, and plant downtime. Currently, utilities seek to achieve burnup roughly 50% higher than in the 1970s, when most of the NRC's criteria and codes for fuel behavior were established. However, at high burnups, fuel pellets and cladding are potentially less resistant to damage under some conditions. These considerations may necessitate modification of (1) fuel rod damage criteria used in NRC regulations and (2) materials properties assumed in safety analyses. Furthermore, new alloys and fabrication procedures designed to counter burnup effects may also affect regulatory criteria and safety analyses. To help address these issues, Argonne is determining the behavior of high-burnup fuel under accident conditions where coolant is lost and is establishing a database for the mechanical properties of high-burnup cladding, which is needed for licensing safety analyses. The Laboratory is also investigating the way high burnup might affect cladding and the behavior of spent fuel during long-term dry storage, a strategy now being

employed at the sites of many nuclear power plants.

The NRC continues to use Argonne's broad expertise in severe-accident phenomena. The Commission was a partner in the recently completed Melt Attack and Coolability Experiment (MACE) program, which was organized by the Electric Power Research Institute. The Laboratory's contributions to this program are described in Section S1.E.1. The NRC will continue to rely on Argonne's expertise in this area through participation in the Melt Coolability and Concrete Interaction program, which is a follow-on to MACE sponsored by the Organization for Economic Cooperation and Development (see Section S1.E.5).

The NRC License Termination Rule provides assurance of public health and safety at nuclear facilities during the termination of licensed operations. To support the development of implementation guidance for the Rule and an associated Standard Review Plan, the NRC is using the Argonne software program RESRAD and has supported its expansion. The expanded program will specifically address the cleanup of contaminated sites and buildings during the decontamination and decommissioning (D&D) of facilities. The software was originally developed for DOE, to help analyze environmental remediation at DOE sites by modeling environmental pathways and the transport of residual radioactive contaminants. This NRC work included extending the existing models for probabilistic dose analyses, thereby allowing NRC licensees to demonstrate compliance with the License Termination Rule and supporting NRC evaluation of the licensees' applications for facility termination.

Argonne is initiating work on an alternative siting rule for NRC to use in evaluating new reactor sites. This rule will be used to evaluate alternatives in the early site permit and combined license applications submitted to NRC.

2. Office of Nuclear Reactor Regulation

Argonne assists the Office of Nuclear Reactor Regulation in a variety of areas related to aging and the performance of materials, components,

structures, and systems in nuclear power plants. This work helps assure that safety will be maintained as plant components age.

Argonne provides technical support to the NRC in the review of license renewal applications in areas including fatigue of metal components, thermal fatigue of cast austenitic stainless steels, irradiation-assisted stress corrosion cracking, and irradiation-induced void swelling.

Argonne participates on interlaboratory teams preparing supplemental environmental impact statements related to the renewal of nuclear plant operating licenses. These analyses have covered issues of land use, ecology, and air quality that are related to continued power plant operations.

The Laboratory is reviewing aging effects and their management for nuclear plant systems, structures, and components that must meet license renewal rules. Previous work contributed to the development of a report and associated standard review plan that serve as guidance documents for NRC reviews of license renewal applications. The Laboratory is currently updating and revising this guidance. Argonne also provides various other kinds of technical support to the Office of Nuclear Reactor Regulation.

3. Office of Nuclear Materials Safety and Safeguards

For the Office of Nuclear Materials Safety and Safeguards, Argonne is modeling environmental and health effects from uranium recovery operations to help the NRC (1) deal with changes in regulatory requirements and (2) consider revisions of existing licenses and applications for new licenses for uranium mining and processing. Enhancements of the current model will take into account *in situ* uranium leaching technology and associated processing. A key issue is the transport of uranium and decay product radionuclides (including radon gas), as well as the associated environmental and health impacts. At the same time, the Laboratory is developing an Internet-based communication mechanism to facilitate distribution of the software code and the NRC's interaction with prospective licensees. In other work, Argonne is helping to prepare an

environmental impact statement for construction and operation of a mixed-oxide fuel fabrication facility to be built at the DOE Savannah River Site. The facility will convert surplus weapons-grade plutonium into mixed-oxide fuel suitable for irradiation in light-water reactors.

B. Department of Defense

Argonne conducts research for several organizations within the Department of Defense (DOD).

1. Office of Secretary of Defense

As simulations of military operations become more accurate, the need for detailed data on terrain to support these simulations has grown dramatically. To provide the required input for the Program Analysis and Evaluation Office, Argonne is developing a sophisticated application for generation of synthetic terrain.

The Laboratory is developing components for the Joint Warfare System (JWARS), a comprehensive modeling and simulation system for analysis, planning, and acquisition. JWARS utilizes existing state-of-the-art models but adds new capabilities, including environmental effects and more comprehensive use of spatial data. An intelligent geographic information manager developed at Argonne will provide unique visualization capabilities by dynamically linking modeled data to various graphic analysis subsystems within JWARS. Argonne also assists in developing components for the Joint Warning and Reporting Network, using the Laboratory's maps and data browser system to display active, vector-based spatial data from sensors and models.

2. U.S. Air Force

The U.S. Air Force sponsors several programs at Argonne. The Laboratory's experience and expertise in conducting environmental assessments of sites with unique environmental features or unique potential impacts are being used for several major proposed Air Force activities.

Argonne is studying biodiversity at a number of Air Force installations across the country, focusing on the abundance of federal- and state-listed species and on the existence of exceptional natural communities. The information collected is incorporated into geographic information systems.

Argonne also performs studies to identify for the Air Force the most cost-effective technical approaches to environmental management. For the Air Force Materiel Command, the Laboratory is developing innovative approaches to computer-assisted management of large numbers of air pollutant emission sources in complex industrial areas. For the Air Force Center of Excellence, the Laboratory is developing approaches for assuring that Air Force actions conform to state and local air quality maintenance strategies. New approaches for environmental management will shift the emphasis from compliance to pollution prevention. In addition, the Laboratory is assisting the Pacific Air Force in its implementation of novel, cost-effective methods for carrying out environmental stewardship, including the management of cultural and natural resources at military installations in the United States and abroad.

Argonne supports a number of programs that serve Air Force Headquarters weather programs. For the Air and Space Natural Environment Executive Agent, the Laboratory evaluates technologies and procedures for the Integrated Natural Environment Authoritative Representation Program. This program generates authoritative environmental databases and models for use by the DOD modeling and simulation community. For the Air Force Combat Climatology Center, Argonne is continuing its development of the Weather Effects for the Warfighter system, an operational planning tool for assessing the impact of the environment on military systems and operations. Also for the Combat Climatology Center, the Laboratory is developing a cluster-based, mesoscale weather forecasting system for use in training and simulation. Simulated weather forecasts from this system will provide a rich training environment for staff weather officers.

As an extension of an earlier project, Argonne is customizing an enhanced version of an advanced information tool to assist the Secretary of the Air Force, Office of the Inspector General,

in handling requests made under the Freedom of Information Act.

3. The Joint Staff

Argonne supports the J-8 Directorate of the Joint Staff by evaluating emerging technologies and applying them to the mission challenges faced by the Joint community in the area of information management for modeling, simulation, and analysis. The Laboratory helps J-8 operations divisions conduct analyses more quickly and reliably by providing advanced simulation and analysis tools and methodologies. The key activities being supported include (1) validation and verification of data and models during the various phases of an analysis; (2) application of object-oriented and agent-based techniques to modeling and simulation; (3) information and knowledge management; (4) development of modeling and simulation architectures that provide interoperability among legacy models, new models, and application packages; (5) development of logistics and deployment simulations; and (6) development of designs and applications for enhancing system security and evaluating new security technologies.

Analysis of logistics and mobility has become increasingly important to the U.S. military because of continuing rapid changes in the ways that forces are deployed. The objectives are lower costs, greater transparency, and more efficient management of the relatively larger and more flexible logistic operations needed for modern warfare. Because more of the U.S. military is now stationed in the continental United States, greater importance is attached to contingency planning for deploying forces, both for missions such as disaster relief and peacekeeping and for military operations. Argonne's work on logistics and deployment modeling and simulation has focused on four areas: developing prototype models and simulations, developing novel system architectures by integrating multiple model and simulation components, conducting technology feasibility studies, and providing technical guidance regarding technologies and systems designs.

The development of modeling and simulation architectures has been a primary focus of

Argonne's work for the Joint Staff since 1987. One of the most useful results has been the Dynamic Information Architecture System, an object-oriented simulation architecture capable of easily interfacing existing models and information processing applications. One notable application is an Integrated Ocean Architecture system that supports U.S. Navy operations.

Another major Argonne object-based framework, FACET (Framework for Addressing Cooperative Extended Transactions) supports the construction of models of complex, cooperative behavior by agents. FACET can be used to implement simulation models of organizational processes, such as the complex interplay of participating individuals and organizations engaged in multiple concurrent transactions in pursuit of their respective goals. Transactions can be patterned on, for example, business practices, government and corporate policies, military standard operating procedures and doctrine, clinical guidelines, or office procedures. FACET can also incorporate other complex behaviors, such as biological life cycles or manufacturing processes.

For the Joint Staff, Argonne also participates in the development of the Complex Adaptive System model to analyze the South American cocaine trade and countervailing law enforcement strategies. In addition, Argonne has participated in the development, design, and implementation of the Analytical Network, for which the Laboratory has integrated advanced-architecture, multi-processor systems and high-performance graphical workstations into the J-8 network and has facilitated achievement of interoperability among components from multiple vendors using multiple protocols.

4. U.S. Army

Argonne (in conjunction with the Federal Emergency Management Agency) assists the Army's implementation of the Chemical Stockpile Emergency Preparedness Program (CSEPP). The Laboratory supports program development, policy analysis and development of associated guidance, emergency preparedness planning, institutional analysis, development of hazard-specific risk communications and emergency public education

mechanisms, and testing and assessment of response capabilities. Argonne also assists in technical management. This work involves hazard analysis; modeling of chemical agent dispersion; development of cost estimation and measurement methodologies; integration for emergency planning; and collection, analysis, and validation of meteorological data at each CSEPP installation.

For the Army Environmental Center, Argonne is conducting research at a series of demonstration sites to develop techniques for the environmental characterization of contaminated installations and for monitoring *in situ* remediation in the continental United States. The research focuses on developing methodologies for characterizing groundwater pathways and contaminant plume configurations that will serve as models for other installations, thereby expediting the selection of remediation technologies and the cleanup or closure of bases at many sites.

For the Waterways Experiment Station of the Army Corps of Engineers, Argonne has provided advanced visualization software to support field sampling; the Laboratory is currently a partner in the Groundwater Modeling System Program. For the Fort Worth District of the Army Corps of Engineers, the Laboratory conducts specialized environmental analyses for water resource projects.

Argonne also helps the Army Corps of Engineers implement projects under Superfund and the Defense Environmental Restoration Program through the Savannah and Kansas City Districts. For the New York and Omaha Districts, the Laboratory is developing specialized approaches to remedial investigations and feasibility studies, particularly for sites with risk of radiological contamination.

Argonne assists several districts of the Army Corps of Engineers in the efficient execution of the Formerly Utilized Sites Remedial Action Program, which was transferred from DOE to the Corps in FY1998. The Laboratory brings specialized technical capabilities to this cleanup program, including the Adaptive Sampling and Analysis Program (ASAP), the RESidual RADioactivity (RESRAD) code for dose assessment, expertise in approaches specified in the *Multi-Agency Radiation Survey and Site Investigation Manual*, multiplatform geophysical

characterization, and advanced tools for management of environmental data.

Argonne is conducting an integrated program of environmental and engineering research and technical support for the Army Corps of Engineers in the Mobile, Baltimore, and New England Districts and at the Army Environmental Center, examining issues such as land restoration, solid waste management, site characterization, detection of buried objects, and cleanup of hazardous waste sites.

For the Army Soldier and Biological Chemical Command, Argonne assists in the development and analysis of restrictions regarding the land disposal of chemical agents and their by-products in the environment. Studies are coordinated with multiple environmental agencies within the Army and with several states. The Laboratory also supports the Command's Assembled Chemical Weapons Assessment Program in the area of environmental compliance for demilitarization of assembled munitions, by exploring alternatives to incineration of material from the U.S. chemical agent stockpile. For the Chemical Demilitarization Program, Argonne investigates chemical methods for (1) analyzing agent standards and waste streams and (2) detecting heavy metals in waste streams. In addition, Argonne is employing models and analyses to address environmental management issues at the Command's Rocky Mountain Arsenal, Pueblo Depot Activity, Tooele Chemical Agent Disposal Facility, and Aberdeen Proving Ground.

Argonne provides technical assistance for environmental restoration activities at the Aberdeen Proving Ground, which has a legacy of chemical contamination. The Laboratory is seeking solutions to such problems through a restoration study at the J Field site and through sitewide remote sensing. Work addresses management of environmental information, wetlands issues, and the natural attenuation of groundwater contamination.

Argonne has undertaken studies of the environmental risks posed by active and former test ranges for the Army Developmental Test Command. The Laboratory is now conducting specific environmental restoration and compliance assessment studies at several installations of the Command

(Dugway Proving Ground, Yuma Proving Ground, and White Sands Missile Range).

Argonne supports the Army Environmental Center through R&D on environmental restoration at various Army installations, including several sites that have been placed on the National Priorities List. Specific activities include development of state-of-the-art environmental data management systems to expedite remedial decision making and use of groundwater and soil gas models to evaluate alternative methods of restoring aquifers. The Laboratory is also supporting compliance and regulatory analyses for the Center, including critical issues related to military munitions and environmental management of military ranges.

For the U.S. Army Defense Ammunition Center (USADAC), a part of the Operations Support Command (OSC), the Laboratory is developing a data system for hazardous waste characterization to support environmental compliance related to the destruction of munitions and explosives at Army installations and to the reuse and recycling of components. In related efforts, Argonne is developing a demilitarization planning and management system that incorporates the USADAC system and other information to improve the Army's ability to plan for cost-effective and environmentally sound demilitarization. In addition, the Laboratory performs specialized environmental modeling and data analyses to address radiological risk and restoration problems at OSC installations (currently the Seneca Army Depot). The Laboratory is also developing the Joint Munitions Planning System, an advanced technology simulation tool for managing the global distribution of munitions.

For the Army National Guard, Argonne provides specialized technical assistance in the analysis of issues related to the environmental management of military ranges, evaluation of the performance of cleanup remedies, innovative site characterization, and modeling of groundwater.

Argonne continues to use its Dynamic Information Architecture System to design and develop integrated modeling systems for ecosystem management by the U.S. Army. The system was applied most recently to modeling the impact of land management decisions at U.S. military installations on resident endangered species. In

particular, for the U.S. Army Engineering R&D Center, the Laboratory developed an agent-based, spatially explicit model for the red-cockaded woodpecker, a bird on the federal list of endangered species.

5. U.S. Navy

The Laboratory supports the Naval Facilities Command (NAVFAC) and the Civil Engineer Corps Officer School in the area of ecological risk assessment, in part by transferring to the Navy restoration program the ecological risk assessment methodologies developed for DOE cleanup programs and also by developing information management systems to increase the efficiency of responses to ecological risk assessments. In addition, the Laboratory provides technical leadership for NAVFAC characterization and risk assessment of depleted uranium in the environment of the Navy's China Lake facility.

6. Defense Threat Reduction Agency

As part of its R&D program in support of arms control and homeland security, Argonne develops treaty verification and threat attribution procedures and technology for the Defense Threat Reduction Agency. Currently, the Laboratory's verification programs focus on the overall long-term information and organizational requirements for verification, validation, and compliance as additional treaties are being implemented. This activity includes analysis of functional requirements, technical evaluation, independent verification, and validation for new automated systems; prototyping for automated training techniques; and assistance in implementation planning. Argonne also conducts life cycle analyses in support of strategic planning for arms control treaty software systems and performs studies and technical evaluations in support of the Open Skies Treaty. Recent additions to the homeland security component of this program include an investigation of methods for attributing a domestic nuclear threat to its perpetrators and a project to evaluate and develop biological microarrays for detecting and analyzing potential biological threats.

7. Defense Advanced Research Projects Agency

As part of the Globus project of the Defense Advanced Research Projects Agency (DARPA), Argonne researchers are developing the fundamental technologies needed to build computational grids. Grid services under investigation include scalable mechanisms for managing resources in distributed systems, an architecture for data management, and basic security algorithms. The long-term goal of the Globus project is to provide basic technology that enables new classes of applications, such as teleimmersion.

As part of the Hybrid Technology Multithreaded Computer Architecture led by the Jet Propulsion Laboratory, Argonne is completing evaluation of petaflops-scale computer architectures.

In other work for DARPA, Argonne is developing oxide thin-film technology for radar and communications systems and biological microchips (biochips) for use as sensors and detectors.

8. Joint Program Office for Special Technology Countermeasures

For the Joint Program Office for Special Technology Countermeasures, Argonne is identifying, collecting, and synthesizing data about the U.S. natural gas, petroleum fuels, and water infrastructures and is developing and applying analytical tools for isolation and system analyses. In addition, the Laboratory is examining trends in the petroleum refining industry, modeling infrastructure interdependencies as complex adaptive systems, and examining risk-based decision methodologies. The overall objective is a capability to identify susceptibilities and operational dependencies in critical infrastructure that, if not remedied, could threaten accomplishment of vital military missions.

C. Department of Health and Human Services

Funding for Argonne's work for the Department of Health and Human Services either flows through the University of Chicago or is received directly through interagency agreements with DOE. (In Chapter VI see University of Chicago Grants and Department of Health and Human Services, respectively.)

University of Chicago Grants

The National Institutes of Health (NIH) supports a broad range of fundamental studies at Argonne. These investigations often apply techniques developed in DOE-supported programs to studies in structural biology, biophysics, carcinogenesis, mutagenesis, and physiology. In turn, the Laboratory's work for NIH benefits its resources for addressing the DOE science mission, including the Department's new Genomes to Life program.

The majority of these studies emphasize structure-function relationships or mechanisms underlying biological responses. Two projects are investigating abnormal regulation of expression of the proliferating cell nuclear antigen gene in "wasted" mice. The objective is to determine whether a deletional mutation in the promoter region of the gene is responsible for the "wst" mutation and the "wasted" phenotype of mice having motor neuron degeneration, radiation sensitivity, and immunodeficiency. These studies also involve the identification and characterization of genes induced in cultured cells following exposure to DNA-damaging agents.

Biophysical studies are addressing the properties of human antibody light chains that lead to pathologic deposition in myeloma. Investigations of *in vitro* aggregation of light chains consider their structure and pathologic characteristics. One project is developing new procedures for the heterologous expression of functional membrane proteins in quantities sufficient for X-ray crystallography to determine the proteins' structures and functions. Another project is investigating the mechanisms by which

cadmium causes bone loss and is relating the findings to human exposure.

Argonne was among the initiators of the structural genomics program in the United States. NIH now is supporting a major new effort in structural genomics at the Laboratory, with an ultimate goal of determining the structures of all protein families. This effort for NIH, in partnership with the DOE-funded Structural Biology Center (SBC) at the Advanced Photon Source (APS), created the Midwest Center for Structural Genomics (MCSG). Argonne is the lead institution in the MCSG consortium, which also includes six universities. NIH will provide approximately \$5 million annually through FY 2005 to establish high-throughput methods for determining the three-dimensional structures of proteins from bacteria and higher eukaryotes. As recently as 1990, solving a single protein crystal structure could take one or more scientists several years. At Argonne, improved techniques for data collection, analysis, and structural determination now allow the structure of a protein to be solved in as little as six hours. Using X-rays from the APS, the SBC collects data of very high quality significantly faster than was possible even a few years ago. By developing (1) robotic methods to carry out tedious experimental procedures and (2) advanced computational methods for analysis of data and structure determination, Argonne has achieved huge leaps in productivity. The MCSG is continuing to develop high-throughput methods in molecular biology, protein purification, and crystallization. Combined with highly efficient SBC beamlines and automated crystallography, these methods will further accelerate the process of determining new protein structures. NIH support of the MCSG will enable further major improvements in productivity.

Interagency Agreements with DOE

The National Institutes of Health is also partnering with Argonne to construct and operate a collaborative access team (GM/CA-CAT) at the APS. This effort will parallel and cooperate with the SBC and the MCSG. Utilizing two undulators and a bending magnet, the new collaborative access team will develop three X-ray beamlines optimized for macromolecular crystallography. Office and laboratory space for staff and users

will be developed in a new office-laboratory module to be constructed at the APS. The beamlines will include high-throughput robotic sample delivery, high-speed data collection with online analysis, and remote access through interactive computer networks. Construction, begun in FY 2002, is planned in two sequential phases that will allow data collection to begin at the first beamline during construction of the other two beamlines.

Argonne provides technical support to the U.S. Public Health Service, Division of Federal Occupational Health, in the development and implementation of an environmental health and safety assessment program for the U.S. Social Security Administration. The principal objective is to develop an overall program framework, plans and protocols, and facility assessments at randomly selected facilities in ten regions. Information gathered during pilot assessments in a few regions will be used to guide subsequent work.

D. Other Federal Agencies

1. Environmental Protection Agency

Argonne applies its Dynamic Information Architecture System as the framework for ecosystem modeling and environmental health assessment through a U.S. Environmental Protection Agency (EPA) system known as MIMS (Multimedia Integrated Modeling System). MIMS allows researchers to consider the environment for nutrients and chemicals across air, water, and land.

For the EPA Office of Pollution Prevention and Toxics and EPA Region V, Argonne is extending methods of analyzing cumulative environmental risks in urban areas by enhancing the availability and performance of scientifically sound procedures, models, analytical tools, and guidelines. One objective is to identify areas within the metropolitan Chicago region where exposures of the general population to individual pollutants or combinations of pollutants might be significant.

For the EPA National Center for Environmental Assessment, Argonne is evaluating

and implementing methodologies related to assessing cumulative risks, including risk of exposures to chemical mixtures by multiple pathways. Applications to DOE sites are being demonstrated.

To calculate radionuclide slope factors useful in predicting incremental cancer risks due to exposure to low levels of radioactive materials, Argonne is assisting the EPA with documentation and implementation of revised radiation dosimetry and risk analysis methods. In addition, Argonne provides guidance documentation, training materials, and fact sheets for the EPA's *Radiation Exposure and Risk Assessment Manual*.

Argonne will assist the EPA Technology Innovation Office with its Triad Program of systematic planning, dynamic work plans, and field analytics, which aims to accelerate environmental cleanup by employing the Laboratory's experience with adaptive sampling, expedited characterizations, and brownfield sites.

For the EPA Region VIII office in Denver, the Laboratory is conducting an environmental site characterization in the Upper Silver Creek watershed near Park City, Utah. This area includes many historic mining sites and is now undergoing major urbanization and resort development. The regional hydrogeology is very complex, with overlapping contaminant sources. Argonne will apply its integrated QuickSite[®] approach at the watershed scale to guide and limit subsequent data collection and to produce a sound regional hydrogeologic model that will support planning and decision making for environmental cleanup.

2. Federal Emergency Management Agency

Argonne's support to the Federal Emergency Management Agency involves three major areas relating to accidental or deliberate releases of chemical, biological, and radiological materials: (1) analysis and evaluation of the capabilities of U.S. industry, nearby communities, and host states to respond to emergencies involving the materials; (2) R&D on guidance for emergency planning, exercises to test emergency plans, and response activities; and (3) the development and conduct of training activities.

3. Department of State and International Atomic Energy Agency

Throughout most of its existence, Argonne has actively supported the worldwide transfer of peaceful applications of nuclear technology. Shortly after the Laboratory was founded, the first international training activities were established as part of the Eisenhower Atoms for Peace program. Participants came from throughout the world to learn about the new, rapidly developing field of nuclear reactor technology. Today, graduates are the leaders of national programs in many countries involving the peaceful applications of nuclear technology.

In 1976, Argonne was designated by the Department of State as host institution for U.S. participation in the new Nuclear Power Training Program of the International Atomic Energy Agency (IAEA). Under this program the Laboratory develops, organizes, and conducts training courses covering a full range of topics in the peaceful applications of nuclear technology. Subject areas include nuclear power, power and research reactor safety, D&D, energy planning, nuclear electronics, isotope hydrology, and environmental monitoring. Approximately 3,000 professionals from over 100 countries, representing essentially all developing member states of the IAEA, have received intensive training through these courses.

Argonne provides technical and management support to the Department of State and directly to the IAEA. One major activity is evaluation of technical cooperation projects proposed for funding by the United States, along with monitoring and facilitation of the implementation of such projects once funded. The Laboratory developed and now maintains — by means of an electronic database — an “institutional memory” of U.S. support for technical cooperation projects, as well as extensive project files, IAEA reports, and evaluation studies. The Laboratory also supports the Department of State and the IAEA in their initiatives to improve the agency’s technical cooperation program. Argonne regularly reviews and analyzes the program’s management and achievements. The Laboratory also develops recommendations on matters of policy or practice related to U.S. support for the program. By

providing experts for technical cooperation programs, Argonne has helped many countries develop the ability to analyze the operation of their energy systems.

A new Argonne project supports the Department of State in analyzing the scientific, regulatory, and environmental aspects of technology related to sustainable development of energy and water systems.

4. Department of Transportation

For the Research and Special Projects Administration, Argonne continues to model the effects of accidents resulting from transportation of chemicals on the nation’s highways and railways. These models will address (1) the effectiveness of establishing protective distances from accidents involving spills on highways and rails and (2) chemical spills into bodies of water from highway and rail accidents. In support of regulation development, the Laboratory is involved in a national assessment of risks (especially risks through inhalation) associated with transporting toxic chemicals.

5. Department of Agriculture

As part of an ongoing program for the Commodity Credit Corporation of the U.S. Department of Agriculture (CCC/USDA), Argonne supports remediation of sites having contaminated groundwater and soil by integrating field sampling, groundwater modeling, and engineering cost analyses. The Laboratory is also developing new cone penetrometer technologies and using them — in combination with innovative sampling, analytical, and computer data processing methods — to map the subsurface distribution of contaminants in soils and groundwater at former CCC/USDA grain storage sites. In addition, Argonne is conducting pilot studies of spray irrigation as an alternative to traditional methods of treating contaminated groundwater.

Argonne is assisting in the technical development of the Research, Education, and Economics Information System (REEIS), a “data mart” that integrates multiple databases in the USDA’s

Research, Education, and Economics program by using a web-based information architecture. REEIS will improve access to information by employing a consistent, integrated framework and will provide automated tools for analyzing the information.

6. National Science Foundation

Funding for most Argonne work for the National Science Foundation (NSF) flows through universities (see Chapter VI).

Argonne is a partner in the National Computational Science Alliance, funded by the NSF Partnerships for Advanced Computational Infrastructure program. Researchers are developing software for collaborative problem solving, distributed computing technology, advanced visualization tools, and parallel input-output technology.

Argonne is one of four institutions participating in the TeraGrid project, which aims to develop the world's first multisite supercomputing system, the Distributed Terascale Facility. The TeraGrid is led by the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign and by the San Diego Supercomputer Center, two leading sites of NSF's Partnerships for Advanced Computational Infrastructure. By integrating the most powerful computers, software, networks, data-access systems, and applications, the TeraGrid will create a unique national resource to support scientific breakthroughs.

As a world leader of emerging grid technologies, Argonne collaborates on several NSF-funded projects, including the Network for Earthquake Engineering Simulation project with the NCSA; the GRIDS Center project with the University of Chicago, the University of Southern California Information Sciences Institute, the University of Illinois at Urbana-Champaign, and the University of Wisconsin; and the Grid Physics Network project with more than two dozen U.S. universities.

The Laboratory participates in a joint NSF-NOAA (National Oceanic and Atmospheric Administration) project examining the importance

for coastal processes of episodic events in the Great Lakes. Argonne's roles in the five-year program include making *in situ* measurements of physical conditions within one meter of the lake bottom and determining very low concentrations of radioactive tracers in lake sediments.

Argonne is leading an NSF-sponsored program, along with Eastern Illinois University and the University of Utah, to develop a digital library collection based on atmospheric visualization. Initial work to demonstrate how visualization can improve access by the educational and research communities to data from the DOE Atmospheric Radiation Measurement Program will facilitate advances in atmospheric boundary layer physics.

7. National Aeronautics and Space Administration

For the National Aeronautics and Space Administration (NASA), Argonne is developing test beds to study applications of distributed computational grids. Argonne researchers, together with investigators at the University of Southern California's Information Sciences Institute, are also teaming with NASA researchers to implement Globus Toolkit technology on the NASA Information Power Grid.

In another project for NASA, the Laboratory is developing and applying an integrated systems approach (involving remote sensing, geochemical and ecological analyses, and hydrologic modeling) to assess, monitor, and model impacts of changes in the landscape and land cover associated with major agricultural development projects in Saharan Africa. Of particular interest are the effects of the development projects on water resources and the production of new carbon sinks. Results from the test site in southwestern Egypt will be applicable throughout the arid regions of North Africa and the Middle East. This work extends ongoing Argonne collaborations with scientists at Cairo University, the Egyptian Ministry of Irrigation and Public Works, and the Egyptian Geological Survey. The work also builds on Laboratory expertise in carbon sequestration developed in projects for DOE's Office of Biological and Environmental Research.

In addition, Argonne is building a state-of-the-art laboratory for trace element detection to study the composition of interstellar dust from supernovas and from comet tails, as well as the composition of components of the solar wind retrieved from Earth satellites. These studies will reveal secrets of the origin and evolution of the universe.

In other work for NASA, Argonne is providing technical assistance and oversight for the Plum Brook Reactor Facilities Decommissioning Project. Four Argonne staff members are serving in the areas of management of construction, quality assurance, health and safety, and radiation safety. This project is expected to continue until 2007.

8. Department of Commerce

Argonne works with two organizations within the Department of Commerce: NOAA and the National Institute of Standards and Technology (NIST).

The Laboratory is collaborating with NOAA's Great Lakes Environmental Research Laboratory and Ohio State University to develop algorithms for interpreting multispectral satellite observations of the Great Lakes. This work involves field studies of the Great Lakes' optical properties and the development of specialized radiative transfer models appropriate for the optically complex waters typical of the Great Lakes.

The NIST Advanced Technology Program (ATP) requires participating private companies to match NIST funding. The private sector can then choose to subcontract to the national laboratories in the pursuit of new technology. (See Section S1.E.2.)

9. Department of the Interior

Argonne provides technical support on environmental issues to the Bureau of Land Management (BLM) of the Department of the Interior, helping BLM maintain long-term stewardship of public lands while allowing production of resources such as oil and natural gas.

Argonne is developing atmospheric dispersion models that will evaluate the effects on regional air quality of enhanced methane production from coal beds in the Powder River Range of Wyoming. Argonne is also funded directly by DOE to support BLM energy planning in the Farmington (New Mexico) and Worland (Wyoming) field offices. These projects test new analytical tools for planning future resource development and management such as computer-generated visualizations of landscape vegetation to assist in planning strategies for controlling wild fires in the western United States.

For the Interior Department's Fish and Wildlife Service, Argonne develops environmental information and communications systems. One of the systems is being developed jointly with the Chicago Wilderness Society.

10. Central Intelligence Agency

For the Central Intelligence Agency, Argonne is investigating ways to extend the lifetime of lithium-ion batteries, in terms of both calendar life and life cycle. New electrode materials are being developed that offer improved stability and greater ability to sustain repeated charges and discharges, yet maintain reversibility.

E. Nonfederal Organizations

1. Electric Power Research Institute

Argonne conducts research for the Electric Power Research Institute (EPRI) on topics related to the risk of a severe accident at a nuclear power plant. Research for the Melt Attack and Coolability Experiment (MACE) program was particularly important. This work investigated the ability of water to quench and cool a pool of molten core debris without formation of a continuous insulating crust, thereby terminating an accident and preventing basement penetration. The investigations attracted worldwide attention because of their importance to strategies for managing accidents at existing plants and their great relevance to design decisions for future light-water reactors. These experiments were sponsored by the 15-nation Advanced

Containment Experiments program headed by EPRI, which pursued realistic understanding of the consequences of an accident involving core melting. A successor to the MACE program is now being conducted under the sponsorship of the Organization for Economic Cooperation and Development. (See discussion of the Melt Coolability and Concrete Interaction program in Section S1.E.5.)

Complementary Argonne programs for EPRI aim to resolve key safety issues through a combination of analysis and experiments. The recently developed computer code CORQUENCH, based on data from Argonne experiments, is being used to analyze accident phenomena.

Other work for EPRI includes identifying and characterizing technologies and processes for mitigating the environmental impacts of cooling water intake structures at electric power plants. Argonne also assesses the use of these technologies and processes in innovative approaches to meeting environmental regulations (e.g., integrating methods such as wetlands restoration, artificial reefs, and artificial supplementation of aquatic systems into strategies such as wetlands banking and effluent trading).

2. Private Firms

Argonne conducts research for a number of private firms, making use of its unique facilities and technical resources. Current work for private firms includes the following:

- Alyeska Pipeline Service Company: An environmental impact statement on renewal of the right-of-way for the Trans-Alaskan Pipeline System, for submittal to the BLM.
- BP Corporation: Development of selective-catalytic-reduction catalysts for treating nitrogen oxides.
- Caterpillar, Inc.: Development of nondestructive evaluation technologies for improving reliability in machining of ceramic valves for low-emission heavy-duty diesel engines.
- General Atomics: Development of a tile computer display wall.

- General Motors Electro-Motive Division: Improving the efficiency and emissions characteristics of diesel engines.

- General Motors Global Alternative Propulsion Center: For advanced vehicles and fuel propulsion systems, analysis of “well-to-wheel” energy efficiencies and emissions of greenhouse gases and criteria pollutants.

- H2Fuel, LLC: Development of a fuel processor for fuel cells that operate on natural gas or propane fuel.

- IBM: Advanced hardware; grid technologies and Access Grid collaborative systems.

- Laerdal Medical Corporation: Development of slurry ice cooling for treating cardiac patients.

- Microsoft: Porting of elements of the Access Grid Toolkit to Windows XP.

- NRG Energy, Inc.: Environmental impact analysis for a 500-kV transmission line.

- Quallion, LLC: Development of an advanced battery for implantable micro-stimulator devices for patients with strokes and Parkinson’s disease. (Funding is from the NIST ATP.)

- Solar Turbines, Inc.: Application of new nondestructive evaluation technologies to ceramic materials being developed for gas-fired turbine engines that emit less pollution and operate more efficiently.

- Superior Graphite Company: Development of nonintrusive controls for an electro-consolidation process intended to replace hot isostatic pressing in the forming of mechanical components. (Funding is from the NIST ATP.)

- Ultralife Batteries, Inc.: Development of advanced lithium battery materials. (Funding is from the NIST ATP.)

In addition to the activities administered under Argonne’s WFO program, as discussed in this Supplement 1, the Laboratory also performs work with its partners in cooperative research and development agreements (CRADAs). These activities are discussed in Supplement 2.

Argonne's work for private firms often grows out of industry-laboratory collaborative projects. A good example is the Argonne Laser Applications Laboratory, which conducts R&D to support the use of high-power lasers. A recent project with the Gas Technology Institute could revolutionize the way we obtain new oil and gas supplies. The project is investigating the use of laser energy in well drilling and well completion techniques. Other projects relate to materials processing for manufacturing, such as laser heat treatment of casting dies. Processing techniques available at the Laser Applications Laboratory include high-power beam shaping and delivery, fiber optics, surface modification, and welding. Industrial partners include automotive manufacturers and suppliers and also several small businesses. One example of benefits to private firms is a low-cost weld monitor being used in a DaimlerChrysler plant in Kokomo. This monitor has saved millions of dollars by improving weld quality. Work by the Laser Applications Laboratory generally supports Argonne's major facilities and programs, such as the APS, the Intense Pulsed Neutron Source, the fusion power program, and D&D of reactor systems. Current work focuses on applying laser ablation in D&D funded by DOE's Environmental Management Science Program.

3. Universities

Current Argonne work for universities includes the following:

- Indiana University: High-performance network connection for research and education.
- Northwestern University: Metacomputing environments for optimization; participation in the Optimization Technology Center.
- Northwestern University: Educational outreach to familiarize science teachers with environmental catalysis and to place Illinois undergraduate students in summer research participation positions at the APS.
- Penn State University: Support for the design and engineering of a cold-neutron multichopper spectrometer for neutron scattering, to be installed at the Spallation

Neutron Source at Oak Ridge National Laboratory.

- University of Chicago: Collaborate to develop a system configuration and design for a passive telepresence node for sites of the National Earthquake Engineering Simulation Grid.
- University of Chicago: Collaborate on the Grid Physics Network project in the areas of data grid and virtual data research, toolkit development, application challenge problems, and outreach.
- University of Chicago: As part of the Illinois Consortium of Accelerator Research project, provide technical support in theoretical and simulation analysis for linear colliders in the areas of ionization cooling of muon beams and advanced schemes for radio frequency photocathode electron beam guns.
- University of Illinois at Urbana-Champaign: Partnership for Advanced Computational Infrastructure program.
- University of Illinois at Urbana-Champaign: Assistance in developing middleware communication services for grid-based collaborations for the project Network for Earthquake Engineering Simulation.
- University of Wisconsin at Milwaukee: Episodic events on the coasts of the Great Lakes.

4. State Governments

For the state of Illinois, Department of Commerce and Community Affairs, Argonne is developing an advanced, high-capacity computer network (I-WIRE) linking major research centers and universities in the state. The network will enable detailed power and engineering feasibility studies, as well as development of advanced interfaces for geographically distributed applications.

Argonne is working under two programs with the Illinois Department of Commerce and Community Affairs. The first involves developing biobased "green" solvents, such as ethyl lactate from corn and methyl soyate from soybeans, for industrial applications. In the second project, the Laboratory is using its widely accepted GREET

(Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) model to estimate full fuel-cycle energy use and emissions from ethanol blends that may be used for light- and heavy-vehicle diesel propulsion.

Argonne is working with the Ohio Department of Natural Resources and DOE-Fossil Energy to develop information management and analysis tools for oil and gas operations.

For the Illinois Commerce Commission, Argonne is beginning a program to analyze the state's electric power transmission system by using a new modeling and simulation approach developed by the Laboratory to study complex adaptive systems.

In another project, the Laboratory is working with DuPage County, Illinois, to develop precollege educational materials focused on recycling.

State groundwater regulatory agencies are prominent members of the nonprofit Ground Water Protection Council, along with federal agencies and other parties interested in protecting the nation's groundwater supplies. Argonne's work for the council involves preparing environmental analyses and developing environmental information management systems, all with a focus on the relationship of energy systems to groundwater protection.

5. International Organizations and Foreign Countries

With the World Bank and countries borrowing from the Bank, Argonne is working on energy and environmental analyses addressing issues such as planning least-cost expansions for electrical generating systems, estimating marginal costs of electricity production, simulating the operation of mixed hydrothermal systems, projecting overall energy supply and demand, analyzing current and future environmental effects of energy production and consumption, estimating the potential for future pollution abatement projects and their costs, and estimating the costs and effects of greenhouse gas mitigation options. Argonne typically conducts these studies in close cooperation with experts in the borrowing countries, who

often are trained to use the analytical techniques themselves.

To advance nuclear reactor technology, international sponsors utilize Argonne's unique capability to perform severe-accident experiments with real reactor materials. The Laboratory currently works with Atomic Energy of Canada, Ltd., on an experiment to explore molten fuel-fluid interaction for the CANDU reactor. The Laboratory is conducting other accident-related research as part of the Melt Coolability and Concrete Interaction program sponsored by the Organization for Economic Cooperation and Development. The technical objectives of this multiyear program are to investigate the mechanisms by which debris cools outside the containment vessel and to address remaining uncertainties related to long-term, two-dimensional interactions between the reactor core and concrete. These objectives will be met through a series of experiments.

In other work, the Japan Nuclear Cycle Development Institute supports studies of the operational characteristics of reactor concepts, the testing needed for advanced fuels, the irradiation behavior of materials, and technology for deactivating liquid metal reactors. The Central Research Institute of the Electric Power Industry of Japan also supports studies of the irradiation behavior of structural materials. Argonne collaborates with the Korea Atomic Energy Research Institute on several aspects of nuclear reactor technology, safety research, and advanced computing applications.

With Egypt's Cairo University, Argonne is investigating the hydrologic impacts of the Tushka Canal in southwest Egypt, which will divert Nile River water currently stored behind the Aswan High Dam to Egypt's western desert in order to reclaim agricultural land. The focus is on (1) impacts to the underlying aquifer and (2) landward migration of the interface between saline water and fresh water that could result when the diversion of water upstream reduces flow in the Nile. The project involves scientists in Cairo University's Center for Environmental Hazard Mitigation. The center was developed with Argonne's aid.

The Laboratory is collaborating with scientists from Costa Rica's National University to evaluate

(1) the quality of urban and semiurban aquifers in that country's central valley, (2) potential sources of pollution, and (3) the extent of urban encroachment along the Atlantic and Pacific coastlines.

Argonne works directly with many foreign countries to provide energy and environmental analyses, along with training in the use of supporting computer models, including two Argonne models, the ENergy and Power Evaluation Program (ENPEP) and the Generation and Transmission Maximizer (GTMax).

In one case the Laboratory is working with the Turkish Electricity Generation-Transmission Company (TEAS) to evaluate development of the Turkish energy system and its environmental impacts. The country's Ministry of Energy and Natural Resources is collaborating with TEAS on this project, which is funded by the World Bank. Included in the analysis is the entire Turkish energy supply system — coal, oil, natural gas, electric power, and renewable resources — as well as all end use sectors.

At the request of DOE and the U.S. embassy in the Dominican Republic, Argonne is working with that country to evaluate its model for restructuring its electricity system.

Argonne is the operating agent for the International Energy Agency program Implementing Agreement for a Co-Operative Programme for Assessing the Impacts of High-Temperature Superconductivity on the Electric Power Sector. The Laboratory's main role is to keep member countries informed about the status of superconductivity research and its progress toward application. The implementing agreement is funded by organizations in 16 countries, including the United States.

Argonne collaborates with Mexico's Petroleos Mexicanos and Universidad Autonoma Metropolitana Unidad Iztapalapa to assess regulatory options for optimizing oil and gas production and environmental protection. Recent collaborations have focused on developing a new framework for regulating drilling wastes from oil and gas exploration and development.

Supplement 2: Technology Transfer

Argonne interacts extensively with researchers from industry, academia, and not-for-profit organizations in pursuit of its technology transfer role to provide technical solutions to energy and environmental problems. Such interactions, in most cases conducted under formal R&D agreements, enhance the Laboratory's programs and provide a means of commercializing the technologies and methodologies created by the Laboratory's researchers. The interactions ultimately enhance U.S. economic productivity, international competitiveness, and society as a whole.

A. R&D Agreements

Argonne's Office of Technology Transfer (OTT) is responsible for ensuring effective transfer of technologies. OTT manages the development of R&D agreements, including cooperative R&D agreements (CRADAs) and "work-for-others" (WFO) agreements; negotiates partnerships and licenses of intellectual property developed by the Laboratory; and serves as a point of contact for inquiries concerning Argonne technology. Table S2.1 summarizes Argonne's technology transfer activities for FY 1999-FY 2001 and projects future activities.

The OTT works closely with the Argonne Partnership Committee, composed of Laboratory research managers who meet regularly in working groups that focus on exploring opportunities for technology transfer to industry and identifying R&D programs that could have commercial impact. Working groups coordinate opportunities in eight focus areas based on the Laboratory's research: (1) transportation technology, (2) materials development, (3) process industries technology, (4) carbon management technology, (5) biotechnology, (6) environmental stewardship, (7) urban technology, and (8) national security.

Argonne aggressively pursues joint research programs and other collaborations with its

operating contractor, the University of Chicago, in order to more effectively utilize the skills of both institutions.

B. Licensing

For Argonne inventions thought to have the greatest commercial potential — on the basis of their uniqueness, value, and timeliness — OTT develops market-based technology commercialization strategies with assistance from Laboratory research divisions. The assessment of commercial potential examines such factors as technical value compared with current alternatives, cost of implementation, industry trends, and overall need for the technology. Through cooperative agreements, the Laboratory collaborates with industrial participants to find the shortest and most productive route to technology commercialization.

Table S2.1 reports income from the licensing of Argonne inventions. Royalties received to date stem from two sources: (1) up-front payments for licenses, options, and assignments and (2) current royalties from product sales. Income shares resulting from the licensing of Argonne technology are first disbursed to inventors and authors. Remaining royalties are transferred to the Laboratory divisions from which the licensed technologies originated, to be used (within policies set in accordance with the *Prime Contract*) for the divisions' internally supported R&D and for educational purposes.

Argonne licenses copyrighted software codes and accompanying documentation to commercial and educational organizations for a fee. In addition, selected software is distributed broadly under free licenses to maximize market impact and benefits to industry. The Laboratory also registers trademarks associated with its software and some invention portfolios, in order to distinguish and protect the intellectual property when it is reported in scientific journals, trade publications, or elsewhere.

Table S2.1 Activities Conducted by Argonne's Office of Technology Transfer

	Actual Values			Projected Values		
	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Office of Technology Transfer						
Funding (\$ in millions)	2.0	2.0	2.3	2.0	2.1	2.2
Staffing (FTEs)	15	16	16	17	17	17
Active Agreements (including amendments)^a						
Cost-shared (CRADAs)	34	27	27	45	40	45
Reimbursable (WFOs and technical service agreements)	234	230	246	271	298	327
With other DOE contractors	308	300	351	360	389	395
Total	576	557	624	676	727	767
Agreement Funding (funds to the Laboratory, \$ in millions)^a						
Cost-shared (CRADAs)	14.7	15.7	12.1	12.0	13.0	15.0
Reimbursable (WFOs and technical service agreements)	66.7	69.1	70.0	86.4	90.7	95.2
With other DOE contractors	36.8	37.5	35.3	48.0	48.0	48.0
Total	118.2	122.3	117.5	143.4	148.7	155.2
Intellectual Property						
Inventions reported	108	111	106	105	105	105
Software reported	14	8	17	12	12	12
Patent applications filed ^b	44	52	47	40	40	40
Patents issued ^b	51	28	46	40	40	40
Active licenses (all sources) ^c	45	78	121	150	175	195
Royalties (gross, \$ in millions)	1.0	0.7	2.4	2.5	2.0	2.1

^aIncludes agreements with both nonfederal and federal organizations.

^bIncludes (1) patent applications filed by Argonne, ARCH Development Corporation, DOE, and others (e.g., inventors and companies) and (2) patents issuing from those filings.

^cIncludes licenses executed by Argonne, ARCH Development Corporation, and DOE.

Since 1999 the Laboratory has made software available online from its Argonne Software Shop (URL: www.softwareshop.anl.gov). Argonne's home page links directly to the shop. The following four popular software packages are currently available:

- LDAP Browser/Editor, a web-based server directory editor. Licenses have been executed with a number of companies, including DreamWorks, Continuum Networks, Grow Network, and Ellacoya.

- GCTool, a thermodynamic modeling software package with several modules, including one for modeling fuel cells. Purchasers of the software include the University of California and the University of Montreal, as well as a commercial company, Allen Engineering.

- PCx, a linear optimizing module used in programming applications. PCx has been licensed to PaperScience, a small business.

- GTMax, a software package used for energy policy management, analysis of spot energy markets, and planning for new energy and electric facilities to meet predicted future demands. GTMax has been licensed to Adica Consulting, a small business.

Argonne has distributed more than 2,000 copies of software to over 50 commercial and government licensees through its Software Shop.

In conjunction with licensing agreements, Argonne often also executes an R&D agreement aimed at precommercial development, through either a WFO agreement (as discussed in Supplement 1) or a CRADA. In FY 2001 the Laboratory executed 27 CRADAs. Other types of agreements, such as personnel exchanges and technical service agreements, are also used when they meet the needs of the Laboratory and its partners.

Some of Argonne's recently executed CRADAs had the following objectives:

- Mack Trucks: Develop a system for using newly developed air separation membranes to produce nitrogen-enriched air in diesel engine combustion.
- Boeing (CRADA amendment): Develop a high-temperature superconducting flywheel suitable for "energy farms" providing short-term energy storage to serve peak energy demands.
- BP-Amoco Chemicals: Further develop Argonne's catalytic process for converting nitrogen oxides, whereby bifunctional catalysis selectively reduces nitrogen oxides by using hydrocarbons for the reducing agent instead of ammonia.
- METSS Corp.: Develop a recycling technology using sink/float experiments to

separate polycarbonate plastics from shredded CDs and DVDs.

- CH2MHill: Assess potential applications of Argonne's Ceramicrete technology for treating hazardous and nuclear waste by generating solid waste forms that are safe for transport and for radioactive chemical waste disposal sites.
- Fuel Cell Energy: Define a low-cost material for bipolar separator plates and anodes in molten carbonate fuel cells.
- Vertec Biosolvents: Develop and test (1) new membrane materials having high ammonia affinity and (2) fluxes used for cracking and esterification of ammonium lactate with alcohols.

C. Non-WFO Funding from the State of Illinois

For the state of Illinois, Department of Commerce and Community Affairs, Argonne is working on two major non-WFO projects. In the first, the state proposes to fund a new building, the Nanoscience Institute Building, to house the Center for Nanoscale Materials (presented as a major Argonne initiative in Section III.A.1); \$2 million for design work was provided in FY 2002, followed by \$17 million for the first phase of construction in FY 2003. An additional \$17 million is planned for FY 2004. In the second project, the state proposes to fund construction of a building to accompany the Rare Isotope Accelerator (RIA, presented as a major Argonne initiative in Section III.A.2). The state provided \$3.6 million to design the building and has appropriated \$13 million for construction. An additional \$3 million is planned for FY 2004.

Supplement 3: Site and Facilities

A. Description of Site and Facilities

1. Overview of Site and Facilities

Argonne National Laboratory conducts basic and technology-directed research at two sites owned by DOE. Argonne-East is located on a 1,500-acre site in DuPage County, Illinois, about 25 miles southwest of Chicago. Argonne-West is located on an 800-acre tract within the Idaho National Engineering and Environmental Laboratory, about 35 miles west of Idaho Falls, Idaho. Argonne-West is devoted mainly to R&D on nuclear technology.

a. Argonne-East

Activities at Argonne-East support the full range of missions described in Chapter II. Major facilities at the site include the Advanced Photon Source (APS), the Laboratory's newest and largest user facility; the Intense Pulsed Neutron Source (IPNS); the Argonne Tandem-Linac Accelerator System (ATLAS); and the Electron Microscopy Center. Researchers from outside Argonne use all these facilities heavily. The Alpha-Gamma Hot Cell Facility supports examinations of materials for major Laboratory programs. Argonne-East also houses a full spectrum of administrative and technical support organizations, as well as DOE's Chicago Operations Office and the New Brunswick Laboratory, both of which use facilities operated and maintained by Argonne.

Altogether, Argonne-East currently houses approximately 4,800 persons, including employees of DOE and contractors and other guests. An additional 2,200 individuals visit the site each year to use the Laboratory's research facilities. The Argonne-East site includes 100 buildings having 4.6 million total square feet of floor space with a replacement value of approximately \$1.1 billion. An additional 200,000 square feet of space is provided by various other structures and facilities throughout the site. The replacement

value of all existing facilities and other structures at Argonne-East is estimated to be over \$1.8 billion. (See Table S3.1.)

Table S3.1 Replacement Value of Argonne Facilities (millions of FY 2000 dollars)

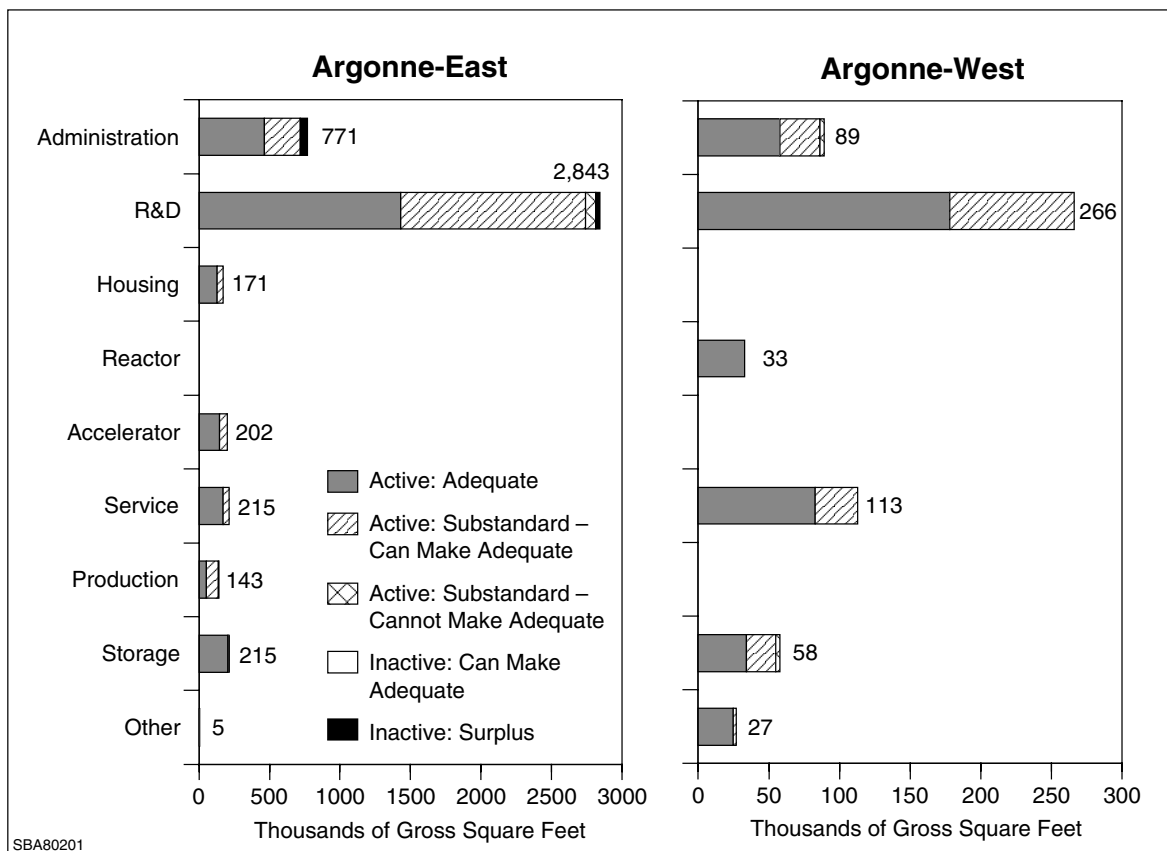
Facilities Type	Argonne-East	Argonne-West
Buildings	1,085	232
Utilities	138	14
All Others	624	192
Total	1,847	438

Research programs supported by DOE's Office of Science account for over half of the space usage at Argonne-East. Figure S3.1 summarizes the distribution of space at Argonne-East (and Argonne-West) by functional unit (administrative, R&D, housing, and so on) and by condition of space, as a percentage of gross square footage.

The Laboratory also leases 77,000 square feet of space near the Argonne-East site to alleviate a space shortage. Other leased property totals an additional 23,000 square feet, primarily for offices in the Washington, D.C., area and in Colorado. Occupancy of off-site space has remained stable for several years.

Adequate land is available to accommodate Argonne's plans for expanded programs in basic research and other areas. The site road and utilities infrastructure generally can accommodate modest growth. Facilities are now almost fully occupied, so additional construction will be required to satisfy the needs of growing programs.

Argonne's long-range vision is to "retool" its physical setting to a 21st-century infrastructure having appropriately configured research facilities that provide reliable, safe, efficient, and attractive working environments suitable for world-class science, engineering, and technical services.



	Space at Argonne-East					Space at Argonne-West		
	Active			Inactive		Active		
	Adequate	Substandard				Adequate	Substandard	
		Can Make Adequate	Cannot Make Adequate	Can Make Adequate	Surplus		Can Make Adequate	Cannot Make Adequate
Administration	463	255	0	0	53	58	28	3
R&D	1,430	1,311	71	0	31	178	88	0
Housing	130	41	0	0	0	0	0	0
Reactor ^a	0	0	0	0	0	33	0	0
Accelerator	145	57	0	0	0	0	0	0
Service	170	45	0	0	0	83	30	0
Production	52	86	5	0	0	0	0	0
Storage	206	6	2	1	0	34	21	3
Other	4	0	1	0	0	25	2	0
TOTAL ^b	2,599	1,801	79	1	83	411	169	6

^aThe reactor building at Argonne-West and some support facilities have been shut down and are being placed in an industrially safe condition.

^bTotals and column entries were rounded independently.

Figure S3.1 Distribution of Space at Argonne-East and Argonne-West in 2002 by Function and Condition (thousands of gross square feet)

b. Argonne-West

Argonne-West conducts R&D and operates facilities for DOE. After termination of the Integral Fast Reactor program in FY 1994, the programmatic mission of the Argonne-West facilities changed significantly. Current primary missions are (1) the use of electrometallurgical techniques to treat driver and blanket assemblies from the Experimental Breeder Reactor-II (EBR-II) and (2) development of technologies for deactivating other sodium-cooled reactors. In addition to Nuclear Energy, Science and Technology, DOE programs using Argonne-West facilities include Environmental Management, Defense Nuclear Nonproliferation, and Defense Programs. The most prominent programmatic facilities and their current missions are described briefly below.

The EBR-II has been shut down and defueled. While it was being placed in an industrially safe, stable condition, it served as a demonstration facility for the development of deactivation methods applicable to other nuclear power plants. One key technology issue still being investigated is treating EBR-II spent fuel to stabilize it, by going from a mixed hazardous waste to a final form that meets the requirements of a geologic repository. This problem is being addressed in the Fuel Conditioning Facility (FCF), where sodium is removed from inside the EBR-II fuel and where the spent fuel is converted from a mixed hazardous waste to a stable metallic and mineral waste form. Resolution of two other technological issues has now been demonstrated. First, large quantities of contaminated sodium were processed into a nonreactive waste form for disposal. Second, a safe process was developed and implemented for controlled reaction of the sodium remaining in the reactor's primary system following drainage.

The FCF, one of the original facilities at Argonne-West, has operated since 1964. A major refurbishment completed in 1996 made the FCF one of DOE's most modern hot cell facilities, meeting current safety and environmental requirements for handling irradiated materials, including transuranics. The FCF has two operating hot cells — one with an air atmosphere for handling contained fuel and the other with an inert

argon atmosphere for conducting operations (including electrorefining) with exposed fuel materials. The FCF is the primary facility involved in applying electrometallurgical technology to the preparation of sodium-bonded spent nuclear fuels for ultimate disposition.

The main cell of the Hot Fuel Examination Facility (HFEF) is a large, multipurpose hot cell filled with inert gas, in which operations on highly radioactive fuels and materials can be performed. The HFEF is being used to prepare ceramic waste products as part of the treatment of sodium-bonded spent fuel. The HFEF is also used for post-irradiation testing of various irradiated fuels and materials, including spent fuel that has become degraded during storage and experimental target rods designed to determine the potential for producing tritium in commercial light-water reactors. The HFEF is an extremely versatile facility that is suitable for such work as examination (nondestructive or destructive) of radioactive materials and development of spent fuel waste forms, as well as for other kinds of work requiring remote handling of radioactive materials. The HFEF was modified in 1999 to accept for examination fuel assemblies as long as those used in commercial reactors.

The Waste Characterization Area (WCA) within the HFEF at Argonne-West is used for sampling and characterizing waste ultimately bound for the Waste Isolation Pilot Plant. The WCA features remote operations and glove boxes for sampling of various kinds, from gas sampling to core drilling.

The Neutron Radiography Reactor Facility, located in the basement of the HFEF facility, is a TRIGA (training, research, isotope, and general atomic) research reactor. It is equipped with two beam tubes and two separate radiography stations, making it one of the finest facilities in the world for radiography of irradiated and unirradiated components.

The Sodium Processing Facility treated sodium from EBR-II and other sources, converting elemental sodium into sodium hydroxide for ultimate disposal. The technology demonstrated could be adapted to processing sodium from other sodium-cooled reactors after they are deactivated,

such as the Fast Flux Test Facility or the BN-350 reactor in Kazakhstan.

The Transient Reactor Test Facility (TREAT) is not currently operating, but the facility is being used to conduct various nondestructive-assay experiments with irradiated materials in containers and shielding casks.

The Zero Power Physics Reactor (ZPPR), now in standby status, was used for physics testing of new reactor core designs. The facility includes a large fuel storage vault that provides state-of-the-art storage for special nuclear materials. Associated Argonne experience in the care and treatment of special nuclear materials has been the basis for efforts to help the former Soviet Union with nonproliferation technology.

The Fuel Manufacturing Facility (FMF), previously used to fabricate fuel for the EBR-II, has completed manufacturing of stainless steel subassemblies for replacement purposes in the defueling of EBR-II. The FMF has glove boxes and a storage vault for special nuclear materials. Equipment for materials testing and characterization is being installed in the glove boxes to support treatment of spent fuel and stabilization of degraded ZPPR fuel plates.

Supporting the major facilities at Argonne-West is an array of shops, warehouses, laboratories, offices, and utility systems. This array of supporting facilities includes a newly refurbished Analytical Chemistry Laboratory with full capability for analyzing irradiated nuclear materials, including transuranics.

Argonne-West houses about 690 persons. The site includes approximately 70 buildings having 600,000 gross square feet of floor space. Figure S3.1 summarizes the distribution of space at Argonne-West by functional unit and condition of space. Most of the buildings and other infrastructure were originally built during the mid to late 1960s but have since been upgraded and expanded. Figure S3.2 summarizes the ages since original construction for Argonne-West facilities. The replacement value of existing facilities at Argonne-West is estimated to be \$438 million. (See Table S3.1.)

2. Status of Existing Facilities and Infrastructure

Because most building and facility infrastructure systems have a useful-life expectancy of 25-35 years, many Argonne facilities constructed in the 1950s and 1960s now require upgrading or replacement. This aging of facilities has caused the accumulation of a large inventory of needed revitalization. Figure S3.2 summarizes the ages of Argonne-East (and Argonne-West) facilities.

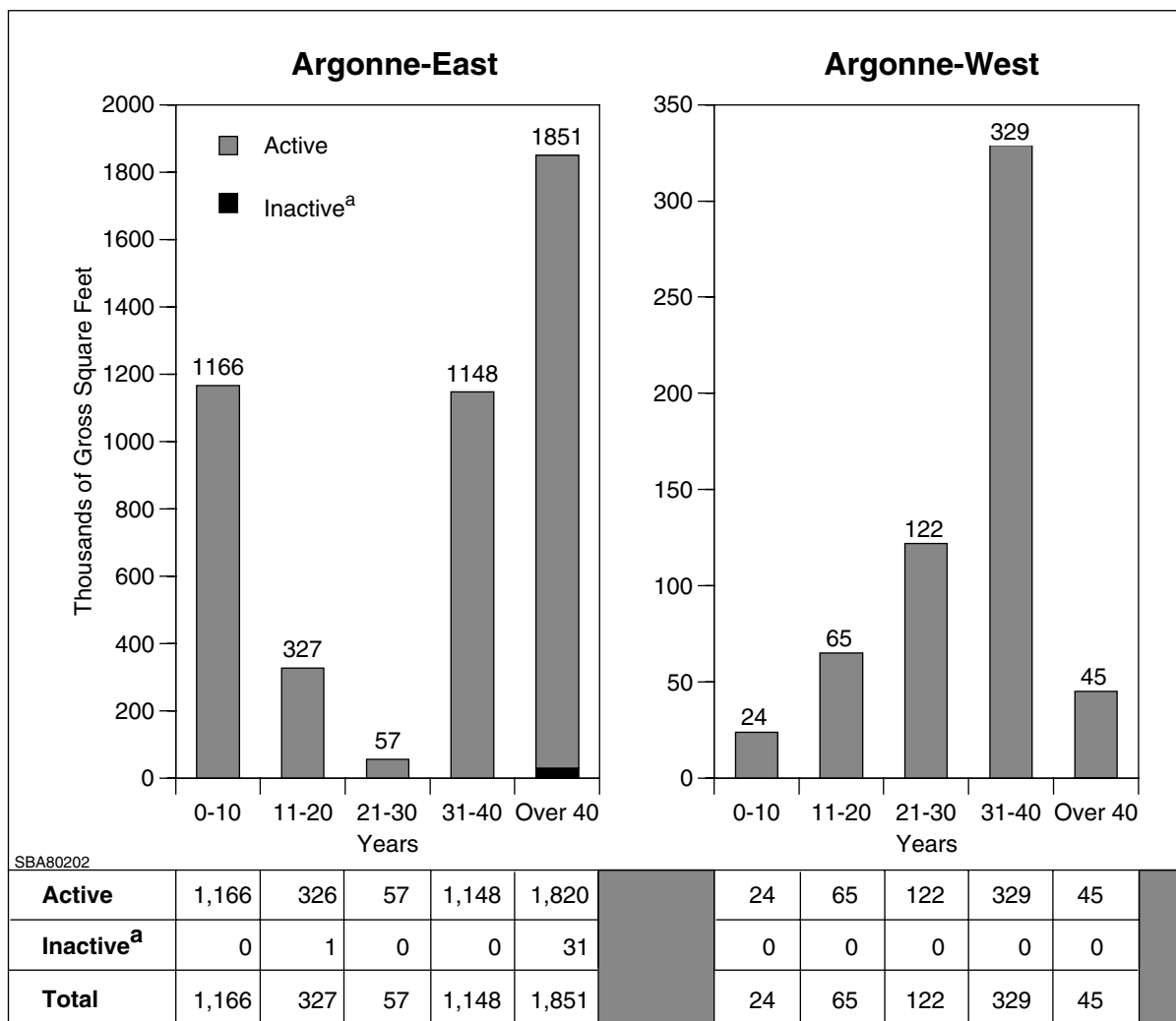
Argonne's management of site and facilities includes a systematic, comprehensive program to ensure that facilities effectively satisfy research needs, as well as requirements for safety, health, security, and environmental acceptability. The Laboratory's ongoing facility planning includes site development planning, the Condition Assessment Survey (CAS) process, and prioritization of resource requirements. The following discussions for Argonne-East and Argonne-West describe the current status of each site in the context of this management program.

a. Argonne-East

The principal challenges being addressed by Argonne-East are the normal aging of buildings and infrastructure and the need to upgrade laboratory facilities to meet 21st-century challenges.

As indicated in Figure V.2 in Chapter V, over 40% of Argonne-East facilities are over 40 years old. Systems and equipment in these older facilities must be upgraded to serve modern R&D adequately. While Argonne-East has made substantial progress in recent years in the rehabilitation and replacement of facilities, the Laboratory's CAS estimates that 39% of occupied Argonne-East facilities still need major rehabilitation or upgrades. Of other facilities space, 43% is considered to be in "adequate" condition, while 4% is "substandard" and requires removal. Figure V.3 in Chapter V summarizes the condition of all types of building space at the two Argonne sites.

Argonne employs a standardized approach to classifying facility condition, based on the cost of



^aInactive space is sometimes too small to be displayed graphically. Entries were rounded independently.

Figure S3.2 Age of Laboratory Buildings at Argonne-East and Argonne-West in 2002 (thousands of gross square feet, distributed by age in years)

rehabilitation compared to the cost of replacement construction. Facilities are classified as “adequate” if the estimated cost ratio of rehabilitation to replacement is less than 10%; “minor rehabilitation” indicates a ratio from 10% to 25%, “major rehabilitation” a ratio from 25% to 60%. When the ratio is greater than 60%, facilities are recommended for replacement or disposal as excess.

Since 1994 Argonne-East has eliminated a substantial amount of inefficient, obsolete space. Fifty-two owned or leased trailers accounting for more than 45,000 gross square feet were removed,

leaving only 11 trailers in use. Also removed were 32 buildings totaling more than 198,000 gross square feet, including six buildings demolished as part of the recent Central Supply Facility project. Currently, approximately 230 staff are housed in a 77,000 square foot rental office facility located about a mile from the site. The lease for the facility is scheduled to end on July 31, 2003. Approximately 1.2% of site space is unused or vacant (not counting space undergoing or scheduled for decontamination and decommissioning [D&D]). The vacancy rate for administrative space (for offices, secretarial

services, support services, and the like) is less than 0.5%. In FY 2001 an additional six surplus facilities were demolished, leaving a total of 100 buildings on the site.

In general, the capacities of site utility systems are adequate for anticipated needs. Still needed are upgrading of sewer system sections not rehabilitated during the 1990s and improvements in the reliability of the site's electrical distribution system. Also needed are improvements to the Central Heating Plant to modernize its auxiliaries and distribution systems, in order to extend the plant's service life and reliability. The general site circulation infrastructure (roads, walks, and parking) is substantially degraded and needs major rehabilitation or outright replacement.

b. Argonne-West

The property management program at Argonne-West aims to (1) meet the needs of the Laboratory's programs; (2) meet environment, safety, security, and health (ESS&H) requirements; (3) provide a workplace that encourages high productivity and creativity; and (4) protect the large government investment in the site's facilities.

The major programmatic facilities at Argonne-West have been well maintained, and all are projected to have useful lives of 15 years or more. General purpose facilities have been maintained in a workable state of repair with limited funds by giving priority to jobs critical or necessary to prevent much more costly future repairs. However, a backlog of needed repairs and rehabilitation that will cost several million dollars has accumulated. Figures S3.1 and S3.2 summarize the condition and age, respectively, of facilities at Argonne-West (and Argonne-East).

B. Site and Facilities Trends

Argonne manages its two sites to maximize the contribution that their physical resources make to the Laboratory's research programs while preserving the sites' environmental settings. This section discusses trends at each site that provide context for understanding the Laboratory's

general plans and strategies for managing its sites and facilities.

1. Argonne-East

Management of site and facilities at Argonne-East must cope with two contradictory major trends. First is the normal aging of buildings and infrastructure in the face of increasing needs for upgrades to meet 21st-century challenges. Second is declining real funding for rehabilitation and upgrades.

For many years, R&D facilities at Argonne-East have accounted for about 60% of total built space. This preponderance of R&D facilities has allowed the Laboratory to adapt well to the shifting research priorities typical of a multiprogram laboratory. The site's R&D buildings today are generally larger, more complex, and more adaptable to changing research programs than they were in the past.

Argonne-East buildings fall into three major groupings having similar ages and needs. The site's original permanent structures, built in the early and mid 1950s, typically need wholesale modernization. The complex of facilities and support areas for the Zero Gradient Synchrotron, built in the 1960s, has been evolving into a collection of special-purpose facilities that today typically need selective modernization. The buildings of the APS complex were built in the mid 1990s and require little modernization.

Figure V.3 in Chapter V indicates that an estimated 43% of occupied Argonne-East space is in adequate condition. Figure S3.3 shows that the percentage of facilities considered to be in adequate condition has trended downward since FY 1998.

Overall, the condition of utilities and other structures and facilities at Argonne-East is unchanged from prior years; that is, minor rehabilitation is required.

Argonne-East has historically received insufficient line-item funding to significantly reduce its backlog of needed upgrades to general purpose facilities. Now, line-item funding for new project starts has been eliminated for FY 2003, and only one new project (an electrical upgrade) is

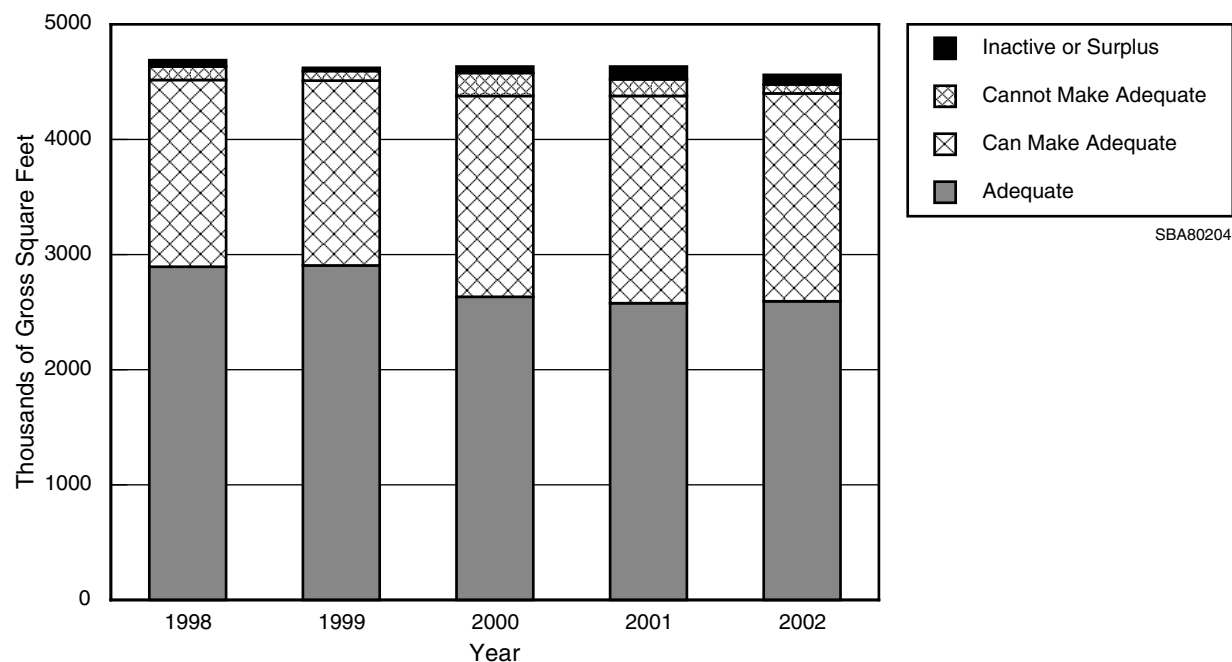


Figure S3.3 Condition of Argonne-East Buildings, 1998-2002

being supported for FY 2004. Delays in funding for urgently needed line-item projects are inordinately burdening the Laboratory's General Purpose Project (GPP) and overhead funds.

Real GPP funding at Argonne-East has also been declining in recent years, causing an increasing backlog of unfunded facility upgrades. The Laboratory has accordingly raised its requests for GPP funds, especially to meet needs documented by its ESS&H and infrastructure (ESSH&I) process. Those needs total \$10.5 million for FY 2003 and \$13.0 million for FY 2004.

Delayed upgrades invariably lead to age-related equipment failures that must be resolved by using limited overhead funds. That strain on overhead funds in turn reduces resources available for routine maintenance and orderly replacement of building equipment. In recent years, 60% of the maintenance at Argonne-East has been corrective rather than scheduled. As reported in the DOE corporate physical assets database (FIMS), actual maintenance costs totaled \$16.9 million in FY 2001 (including \$10.5 million for buildings and \$6.4 million for other structures and facilities); deferred maintenance totaled an additional \$19.9 million (\$15.8 million for

buildings, plus \$4.1 million for other structures and facilities). Estimated annual maintenance requirements for FY 2002 were \$17.6 million.

The information technology equipment that serves as the backbone for electronic data communication at Argonne-East is rapidly becoming obsolete. Most of the computing equipment that supports the network infrastructure and manages the site's administrative data (including environmental and facilities information) has reached the end of its useful life. Current capabilities are insufficient to manage all required administrative data effectively and support R&D optimally.

Insufficient General Purpose Equipment (GPE) funding over the past decade has led to serious aging and obsolescence of equipment for support activities and an inability to introduce needed major new equipment in a timely manner. Excluding laboratory equipment, the site's general plant equipment is on average 72% depreciated (asset value weighted). For equipment that is not already fully depreciated, the average remaining life expectancy is approximately 3.5 years. Extrapolation of recent funding trends implies that the Laboratory will continue to be unable to

replace general purpose equipment at recommended rates.

Site and facility plans in the next two sections are based on the Laboratory's needs to upgrade its aging infrastructure to meet the challenges of the 21st century. Their success requires a reversal of current funding trends.

2. Argonne-West

The Argonne-West site includes 70 buildings and 8 government-owned trailers that altogether have a total floor space of approximately 600,000 gross square feet. (The 8 trailers provide approximately 4,850 square feet.) Most of the buildings and infrastructure were built during the mid to late 1960s. A new fire station (9,240 square feet) was completed during 1998. Total space at the site has increased only slightly in recent years. The expected trend is to maintain and possibly modify existing facilities for current and future missions. All trailers are currently in use, but long-run plans call for their removal.

As Argonne-West facilities have aged, the cost of recommended maintenance has increased. However, maintenance funding received has remained stable or declined slightly.

Currently, there are no surplus facilities at Argonne-West, but that situation might change when deactivation of EBR-II is complete. All facilities at the site are presently used to support R&D programs.

C. Facility Management Operating Strategies

Argonne remains fully committed to its formal strategic facilities planning processes for site development and management of facilities and real property assets. Argonne's sites and facilities support the execution of world-class basic and technology-directed research by providing reliable, efficient, cost-effective facilities offering work environments that are safe, secure, healthful, and environmentally sound and that generally stimulate creativity and high productivity.

1. Argonne-East

Three major goals and associated strategies support the Argonne-East vision for the 21st century: (1) maintain excellence in ESS&H, (2) ensure effective use of facilities and systems, and (3) maintain a setting suitable for world-class research.

a. Maintain Excellence in ESS&H

Argonne strives to comply with federal codes, standards, and regulations, both in ongoing operations and in the design, review, and construction of future facilities. The Argonne-East prioritization process for ESS&H focuses management attention on the most urgent infrastructure requirements.

Environmental restoration undertaken by Argonne has characterized and contained most formerly contaminated areas and waste disposal and storage sites. Corrective actions currently under way include remediation and monitoring to assure environmental quality. The D&D of contaminated reactors, accelerators, and hot cell facilities at Argonne-East aims to return these facilities to the site's space inventory, to the extent practical.

b. Ensure Effective Use of Facilities and Systems

Argonne-East employs several management strategies to ensure the effective use of its existing facilities.

Landlord and tenant roles are clearly delineated. The Plant Facilities and Services Division functions as landlord for the site, with responsibility for all aspects of the general purpose physical plant, including operation, maintenance, and compliance with ESS&H regulations. This approach ensures balanced, comprehensive prioritization of attention to all Laboratory facilities. Facility occupants are responsible for managing, maintaining, and repairing their own specialized equipment, experimental apparatus, and systems dedicated to programmatic activities, including ESS&H aspects of such equipment and systems.

Site development planning supports the efficient use of land and facilities. This planning is closely linked to the institutional planning process and to application of the CAS to existing facilities.

Land use planning considers natural aesthetics, as well as future development of major programmatic initiatives within dedicated development areas of the site. (See, for example, Section III.A.2 for discussion of the Rare Isotope Accelerator as a proposed expansion of ATLAS.)

Argonne-East manages its space to meet the needs of its research programs while satisfying General Services Administration guidelines, thereby maximizing occupancy rates and routinely accommodating changes in research programs. The Laboratory's clearly defined space management program requires that each organization pay rent based on the square footage of space occupied. Occupancy charges paid by all site users are based on operational and maintenance costs calculated for the individual facility. In FY 2002 these costs averaged approximately \$5.90 per gross square foot. Utility use is metered and the cost passed on proportionately to facility occupants, if it is not directly charged to the operators of metered equipment. This system gives research programs a strong incentive to keep space usage to a minimum.

The Laboratory's CAS uses industry and DOE standards to systematically evaluate the condition of the physical plant. Assessments performed by outside specialists provide a credible, auditable basis for determining physical plant needs. Each facility or utility is surveyed every three to five years, and a life-cycle-based ten-year forecast of needs is developed. These assessments use standard cost estimating data, and needs are rated by using the Capital Asset Management Process (CAMP) scoring system. Utilization of outside specialists provides an independent, auditable basis for determining physical plant needs.

Further inspections and assessments performed include environmental surveys; safety and environmental audits and inspections; monthly life safety inspections; and semiannual environment, safety, and health inspections. Imminent dangers are corrected immediately. All safety inspection findings are tracked until they

are resolved. The Laboratory's suite of internal, independent inspections ensures that facility deficiencies are identified and evaluated quickly and are corrected on the most advantageous schedule possible.

Argonne's ESSH&I prioritization process focuses on prioritizing the needs identified by the complementary processes discussed above. Facility needs are regularly analyzed, integrated into a single list, and prioritized by representatives of all facility stakeholders, including programmatic organizations. This integration and prioritization process has been formalized and documented. It includes representation from all support and programmatic personnel, up to the Laboratory's most senior level. Communication and agreement with DOE and other stakeholders help ensure comprehensive evaluation of facility needs, in preparation for the annual development of funding plans and the systematically prioritized use of limited resources.

Argonne manages some of the programmatic obsolescence of its facilities by simple reprogramming for a new use or remodeling and rehabilitation for reuse to meet a current need. A recent example is reuse of the Experimental Boiling Water facility, after D&D, as the Radioactive Waste Storage Facility. That reprogramming freed maintenance funds for productive use elsewhere.

Replacement of outmoded facilities with more efficient facilities reduces maintenance and overall operating cost. Demolition of surplus facilities and equipment reduces surveillance and maintenance costs and makes land available for reuse. For example, the east area and the 800 area of the site are now ready for redevelopment and reprogramming.

c. Maintain a Setting for World-Class Research

Achievement of world-class research is fostered by appropriate settings, both for the immediate workplace and for the surrounding campus. Argonne's goal is modern, flexibly appointed research and support facilities whose designs take advantage of the latest construction technologies to achieve sustainability, flexibility,

versatility, and longevity. The new Central Supply Facility is a good example of the application of sustainable design and integration of facilities.

In order to maintain facilities that are an appropriate setting for world-class research, the Laboratory appropriately enhances both the functionality and appearance of interior work space, which helps to attract superior scientists and engineers and then contributes to their productivity and creativity. Projects undertaken include renovation of public areas, upgrades to increase accessibility, improvements of lobbies and conference facilities, modifications to landscaping and parking areas, and general enhancement of the site's appearance to reflect its world-class status.

Argonne-East has been notably successful in integrating its development pattern into the site's natural landscape and making the buildings in each area aesthetically compatible. Argonne-East is protecting environmentally sensitive areas of the site in their natural state, especially along existing natural areas, floodplains, streams, and steep slopes. Former ecology plots are being managed to enhance their natural biodiversity, which contributes to the park-like setting. These plots remain available as a strategic reserve for programmatic development that cannot be accommodated elsewhere on the site.

The campus-like ambience of Argonne-East has been enhanced by a site beautification program, the use of common architectural elements to unite various areas visually, and demolition of temporary and aged facilities, such as the large number of trailers employed earlier.

2. Argonne-West

Argonne-West conducts R&D programs that support the Laboratory's overall mission in nuclear technology. Those programs currently have two major components. The first is termination of the Integral Fast Reactor program and associated activities, including shutting down EBR-II. The second component addresses issues such as the treatment of spent nuclear fuel, reactor and fuel cycle safety, and development of technologies for deactivating reactors and other nuclear facilities.

Environmental activities command high priority at Argonne. The objective of the environmental program at Argonne-West is to ensure no adverse effect to the environment and compliance with environmental regulations. Major activities include (1) sampling, analyzing, and remediating past releases of hazardous materials into ponds, ditches, and other areas; (2) replacing underground pipes and tanks; (3) upgrading the radioactive scrap and waste facility with cathodic protection; (4) seeking permits from the U.S. Environmental Protection Agency and the state of Idaho for certain ongoing activities; (5) developing a facility for remotely handled mixed transuranic waste; and (6) converting elemental sodium into solid sodium hydroxide for disposal.

As funding allows, Argonne-West performs regular maintenance on its facilities and upgrades them to meet the needs of its R&D programs. Preventing deterioration of facilities and costly failures will require continued maintenance and rehabilitation of roofs, roads, sidewalks, and steam and condensate lines, as well as systems for cooling water, water supply, storm drainage, radioactive liquid waste, electricity, communications, and other purposes.

D. Planning Approach for General Purpose Infrastructure

Argonne's planning for general purpose infrastructure focuses on maintaining facilities that are both safe and efficient, upgrading R&D facilities to 21st-century standards, and providing adequate utilities and transportation networks. This section describes the Laboratory's overall planning approach. Subsequent sections describe particular resource requirements.

1. Argonne-East

The Argonne-East site can physically accommodate facilities aggregating to two to three times the present state of development. Environmentally sensitive and interconnecting open-space areas that support the natural ecology and hydrologic drainage of the site are being retained in their natural condition. The intensity of

planned development on the balance of the site — in terms of covered area, floor area ratio, and landscaping standards — will remain consistent with the character of areas already developed.

Achieving the Laboratory's strategic vision for the 21st century begins by eliminating deficiencies in existing facilities due to aging and obsolescence. Beyond restoring impaired functionality, the Laboratory must upgrade telecommunications, improve building electrical and mechanical services, and modernize the layouts and furnishings of laboratory space. Maintaining and upgrading sound but depreciated facilities is central to Argonne's operating strategy for existing general purpose facilities. Also proposed are construction of essential new facilities and disposal or replacement of inefficient structures.

The primary focus of building systems upgrades and modernization is the older multiprogram laboratory-office buildings in the 200 and 300 areas. Two-thirds of the space in these buildings requires major rehabilitation; another 20% requires minor to moderate rehabilitation. Twelve buildings totaling 2 million gross square feet (including Buildings 200, 201, 202, 203, 205, 206, 208, 212, 221, 223, 360, and 362) account for the bulk of the modernization requirements.

Argonne-East plans to implement its upgrading and modernization programs in rotating phases that concurrently address common system needs across several buildings. Broadly speaking, building electrical systems will be upgraded for reliability and load capacity. Mechanical and control equipment and distribution systems will be improved to provide a more flexible and adaptable building utility support network. The final stage is to reconfigure, rehabilitate, and modernize space partitioning, laboratory furnishings, and architectural features. Argonne plans to implement modernization in wings or floors of buildings, so that entire buildings need not be shut down; however, a multiprogram laboratory-office building is needed to accommodate personnel and research activities displaced during the ten-year course of modernization.

Two other new facilities are needed at Argonne-East. First, a multiprogram computa-

tional facility will consolidate massive parallel computing systems and provide a hub serving computational technology being incorporated into modernization projects throughout the site. Second, a new general purpose high bay facility is needed to supplement current facilities and to consolidate R&D during the upgrades to other high bay facilities discussed below.

Aging high bay facilities suffer from many of the same problems as research laboratories. Particularly needed is more effective control of temperature and humidity. Most existing high bays have little insulation and old suspended mercury vapor lamps. Midwestern temperature extremes, in both winter and summer, affect work in many high bay facilities, including the IPNS accelerator in Building 375, the assembly area in Building 366, and work spaces in Buildings 306 and 363. It is important that these buildings be provided with adequate heating, air conditioning, and humidity control and be made energy efficient.

The roads and utility systems at Argonne-East require further rehabilitation but are adequate for future expansion. Major rehabilitation of roadways and parking lots has not been undertaken in nearly 20 years. The general site circulation infrastructure — roads, walks, and parking — is substantially degraded and needs major rehabilitation or outright replacement. Operating funding alone is not sufficient to restore the paved surfaces in a timely fashion.

Portions of major utilities also need rehabilitation, most notably the laboratory and sanitary sewer systems that were not fully restored in the 1990s. At the Central Heating Plant, auxiliary systems and components require upgrading during this planning period to extend service life and reliability. The site's electrical distribution system requires additional equipment upgrades to achieve reliability during maintenance shutdowns or unplanned service conditions, thereby assuring uninterrupted service to R&D facilities.

Within the Laboratory's aggressive plan for rehabilitating and modernizing site buildings, the replacement of roofs is the highest priority for FY 2005. Many roofs have reached the end of their design life, and repair and replacement costs

are beginning to escalate. Also needed are upgrades to sitewide communications, so that the federal mandate of all-digital communications by January 2005 can be met. These upgrades currently are not being supported.

Argonne-East envisions demolition of Buildings 40, 301, and 604. Demolition of Building 330 is complicated by residual contamination that was not removed by the D&D project funded by DOE-Environmental Management (DOE-EM). DOE-EM has suspended funding for D&D and is not expected to restore any funding until FY 2007, which will delay elimination of some environment, safety, and health liabilities for at least another five years. By that time the Laboratory expects to be in a position to undertake D&D and demolition of the M-Wing hot cells in Building 200. However, DOE-EM is providing funding for surveillance and maintenance of Building 301, the Juggernaut Reactor in Building 335, and the ZPR Reactor area in Building 315.

2. Argonne-West

At Argonne-West, the main issue for general purpose facilities is facility aging, with its normal attendant requirements for upkeep and renovation. Now being planned are facility additions and modifications required for programmatic support, including environmental activities, waste handling, and related efforts. Correction of facility-related deficiencies is also a planning focus.

E. Facilities Resource Requirements

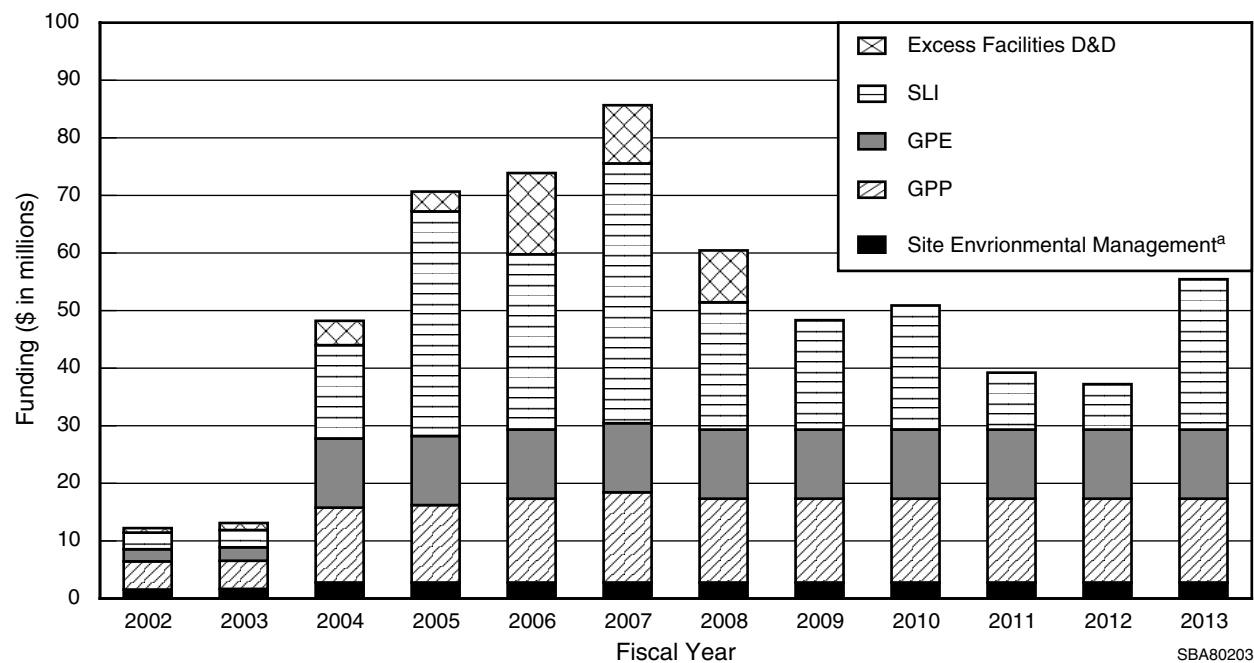
Argonne has historically received only part of the funding needed for (1) construction of infrastructure improvements and replacement facilities and (2) remediation and upgrades to correct ESS&H and other deficiencies. This section discusses the particular projects needed to achieve the Laboratory's vision of a 21st-century infrastructure.

1. Argonne-East

Funding received through the Science Laboratories Infrastructure program (SLI, formerly the Multiprogram Energy Laboratory–Facility Support or MEL-FS program) and the GPP program allows Argonne-East to replace or rehabilitate functionally important or deteriorated elements of the site's infrastructure. These important facilities serve a wide variety of changing research programs and national user facilities, as well as support services and administrative functions needed to carry out the broad mandate of a multiprogram laboratory. The ability of Argonne-East facilities to continue functioning safely, efficiently, and economically depends on sustained support from DOE infrastructure funding (leaving aside Building 350, which is dedicated solely to DOE's New Brunswick Laboratory).

Recommended funding to support the projects described in this section is described in Table S3.2 (located at the end of this supplement because of its length). The table also describes recommended GPP and GPE funding. These funding recommendations are consistent with the FY 2002 10-year *Strategic Facilities Plan* for Argonne-East, which specifies the infrastructure modernization needed to support current and planned mission activities in a cost-effective, safe, secure, and productive manner.

Figure S3.4 graphically summarizes total funding requirements for all infrastructure modernization needs at Argonne-East. The figure shows total ten-year (FY 2004-FY 2013) capital funding needs of approximately \$500 million, consisting of \$238 million from DOE's SLI program, \$144 million from the GPP program, and \$120 million from the GPE program. (These three DOE programs are discussed in the subsections immediately below.) In addition, Figure S3.4 shows \$41 million for D&D and demolition of excess, inactive surplus, or contaminated facilities, plus \$28 million for site environmental management at Argonne-East. (See the discussion of Inactive Surplus Facilities in Section S3.F.3.a.) The Laboratory proposes that these two activities be supported by direct operating funding apart from that provided by DOE-EM. Beyond the



	0.8	1.2	4.2	3.5	14.1	10.1	9.0	0.0	0.0	0.0	0.0	0.0
	2.8	3.0	16.2	39.0	30.5	45.2	22.1	19.0	21.6	9.9	7.9	26.1
	2.2	2.3	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
	4.8	4.9	13.0	13.4	14.5	15.6	14.5	14.5	14.5	14.5	14.5	14.5
	1.6	1.7	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Total	12.3	13.1	48.2	70.7	73.9	85.7	60.4	48.3	50.9	39.2	37.2	55.4

^aA small amount of Laboratory indirect funding devoted to site environmental management in FY02-FY03 is not reported here.

Figure S3.4 Capital Funding Requirements for Argonne-East, FY 2002-FY 2013

infrastructure modernization investments by DOE summarized in Figure S3.4, maintenance at Argonne-East is supported by Laboratory indirect funding, which is projected at approximately \$17 million annually (see Section S3.E.1.d).

year planning horizon FY 2003-FY 2008 to total \$153 million, including \$50.2 million for new facilities and \$102.7 million for rehabilitation and modernization of existing facilities. The line-item projects included are summarized below.

a. Science Laboratories Infrastructure Program

The SLI program has provided an important part of recent funding for rehabilitation of major buildings and utility systems at Argonne-East, as well as funding for construction of new general purpose facilities. Total SLI funding has averaged \$6.5 million annually since 1995. The Laboratory estimates future line-item SLI needs over the six-

i. New General Purpose Facilities

Multiprogram Laboratory and Office Building. This project provides for the design and construction of a Multiprogram Laboratory and Office Building (50,000 square feet). Systems and components will be designed to minimize life cycle costs and improve environmental performance. The building will facilitate the rehabilitation of laboratory and office space in

other buildings by temporarily housing dislocated activities, which is currently difficult to do.

Multiprogram Computational Facility. This project will provide a computational center (40,000 square feet) as a focus for massively parallel computers and simulation technologies. In existing facilities, computers cannot be co-located with virtual-reality equipment in a way that adequately allows for expansion and reconfiguration.

General Purpose Laboratory Facility. This project will provide a flexible high bay research facility (25,000 square feet) to supplement current facilities and to meet changing needs more readily. A freestanding location will facilitate expansion and reconfiguration and will achieve proximity to laboratory space with minimal physical obstructions. These capabilities cannot be achieved through rehabilitation or reprogramming of existing high bay areas, because of the resulting disruption of current work and the type of construction used in the existing buildings.

ii. Building Rehabilitation and Upgrades — Existing Facilities

Building Roof Replacement. This project involves comprehensive replacement of the roofing systems on older buildings, including all original buildings in the 200 and 300 areas and buildings constructed between 1970 and 1990. The last comprehensive roof replacement at Argonne-East occurred between 1983 and 1987 and used roofing systems with a predicted life of 20 years. Repair of small leaks is now necessary with increasing frequency.

Building Electrical Service Upgrades — Phases II-V. These projects will upgrade critical parts of the electrical power distribution system in the 200, 300, and 360 areas and their support facilities. The systems will be updated to meet current safety standards, to improve reliability and performance, to support new research programs, and to reduce maintenance and repair costs. The work will include (1) upgrading of lighting and power panel boards, 13.2-kV switches, 480-V switchgear, and transformers and (2) the provision of emergency power for selected buildings. Particularly important will be replacing 13.2-kV switches and 480-V switchgear with new

equipment having state-of-the-art metering and protection devices.

Mechanical and Control Systems Upgrades — Phases I-IV. This series of four projects will upgrade critical parts of mechanical and control systems. The projects involve rehabilitation and upgrading of heating, ventilation, and air conditioning systems; exhaust systems; drainage systems; and controls to address concerns such as reliability of operations and environmental protection. Phase I was funded to begin in FY 2002.

Laboratory Space Upgrades — Phases I-III. These projects encompass essentially all aspects of modernizing laboratory space, including reconfiguration and upgrading of laboratory space envelopes; laboratory interiors; work area furnishings; communications, security, and electrical distribution systems; plumbing systems; and laboratory and process piping. The projects address safety and health concerns by including upgrades of fume hoods, vacuum frame hoods, canopy hoods, and glove boxes, along with associated utilities. Also included are removal and disposal of potentially contaminated or hazardous materials such as hoods, exhaust ductwork, piping, and asbestos insulation.

iii. Utilities and Site Infrastructure Upgrades

Central Heating Plant Auxiliaries Upgrade. Upgrading of the steam production auxiliary systems and components at the Central Heating Plant will improve reliability and performance of the steam production process. The project will save both energy and operating costs, and it may be undertaken as an energy conservation project under third-party financing.

Sitewide Communications System Upgrade. Argonne-East anticipates installing a fully integrated voice-data-video-wireless sitewide communications system by January 2005, when system replacement becomes mandatory. The new system will combine traditional PBX (private branch exchange) features with capabilities for data switching, video teleconferencing, wireless service, and Internet access.

Roads, Parking, Walks, Street Lighting. Many roads, parking lots, and sidewalks at Argonne-East

have deteriorated beyond amenability to general maintenance and basic repair. Other areas require additional parking and walkways. This project will rehabilitate or upgrade the surfaces of selected roads, parking lots, and sidewalks (and will use recycled materials where possible). The project will also replace inefficient lighting along streets and around parking lots and building exteriors. A new sitewide high-pressure sodium lighting system will cut electrical loads by approximately half and will provide better coverage at roadway intersections and in parking lots.

Electrical System Upgrade — Phase IV. This project will upgrade 5-kV overhead lines to 13.2 kV and will increase the capacity of the 13-kV overhead lines in the 200, 300, and 400 areas. The project will also replace 13.2-kV switchgear and interrupter switch lineups that serve the 300 area, increase the capacity of transformer T3, and replace transformer T6. Outdoor automatic transfer switches will be installed to serve Buildings 201 and 221. Most importantly, additional electrical service capacity will be brought to the site distribution system from Commonwealth Edison's supply grid, allowing increased reliability and service levels.

iv. Environment, Safety, and Health Support Projects

Fire Safety Improvements — Phase V. This project addresses remaining capital improvements needed for fire protection. Work includes correction of deficiencies affecting property protection and potential interruption of work, installation or upgrading of fire barriers, replacement of halon systems and obsolete building sprinkler water supply connections, and repair of hydraulically deficient sprinkler systems not related to life safety.

Building 362 Asbestos Abatement. Asbestos-containing materials (ACMs) are present in numerous older buildings at Argonne-East. Damaged ACMs threaten building occupants and workers and must be repaired or removed; undamaged ACMs may be left undisturbed or sealed. This project will remove asbestos fireproofing materials now under floor decks and attached to steel structural elements in

Building 362. Where needed, the project will clean up friable asbestos.

b. General Plant Projects Funding

At Argonne-East, GPP funding averaging approximately \$4.7 million annually in FY 1996-FY 2001 has supported urgently needed facility modifications and upgrades and replacement of equipment. GPP funding also supports environmental projects, near-term infrastructure improvements, and key safety upgrades. In general, GPP funds are crucial for work that goes beyond short-term maintenance and repair but must be undertaken more quickly than would be allowed by the normal lead times for line-item construction projects. GPP funding does not support particular R&D programs.

Historically, GPP funding received by Argonne has been inadequate to address infrastructure and modernization needs. Requirements over the six-year planning horizon of the *Institutional Plan* total \$76 million, more than 2.5 times greater than current funding levels.

Strategic application of GPP funds continues to fall into three general areas. First, the recent practice of applying GPP funds to smaller-scale upgrades and modifications of buildings will continue. These projects modernize smaller buildings and implement less extensive reconfigurations, thereby complementing larger-scale renovations.

Second, GPP funding will support upgrades to sitewide utility systems at selected locations. These systems include laboratory and sanitary sewer collection systems that were not completely rehabilitated under earlier projects supported by DOE-EM. Upgrades undertaken will also include continuing improvements to the canal water and storm water systems.

Third, GPP funding will complement line-item funding by supporting construction of smaller new facilities costing less than \$5 million. GPP funding will also support construction of new general purpose support facilities. Examples are a replacement facility for the Emergency Services Department (Building 333) and replacement of scattered, older, contaminated storage facilities

that are still active (i.e., Buildings 325C, 329, and 374A) with a better located, more efficient, centralized waste storage facility. These replacement facilities are envisioned to increase operational efficiencies without significantly changing the total building space involved.

c. General Purpose Equipment Funding

General Purpose Equipment funds will be used for vital support purchases, including (1) plant maintenance monitoring equipment; (2) operating equipment meeting current ESS&H standards; (3) equipment for monitoring and controlling release of effluents to the environment; (4) motor vehicles; and (5) technological support in areas such as computing, electronic data communications, cyber security, machine shops, and electronics.

Beginning in FY 2004, the annual GPE funding requirements of Argonne-East are \$12 million, as shown in Table S3.3. Increases over current funding levels are required for purposes such as appropriately configuring and updating computer simulation equipment and high-bandwidth hubs. The increased funding level will allow the Laboratory to take advantage of current technologies and to satisfy researchers' increasing needs for computer simulation. The increase will also be used to acquire and rehabilitate general purpose equipment (but not to support specific R&D programs).

Table S3.3 Proposed General Purpose Equipment Funding for Argonne-East (\$ in millions BA)

FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08
2.2	1.6	2.3	12.0	12.0	12.0	12.0	12.0

d. Maintenance Funding

Approximately 60% of maintenance at Argonne-East is devoted to corrective maintenance, as opposed to recurring, operational, or preventive maintenance. This situation reflects the large proportion of equipment that is still operating beyond its normal service life.

Modernization of older equipment will lessen the current need for emergency or urgent corrective maintenance, allowing the Laboratory to focus on preventive maintenance that lengthens the service life of equipment and reduces costs in the long run.

Maintenance funding will remain stable at approximately \$17 million annually for real property maintenance. Replacement plant value is expected to increase only slowly, following general inflation trends, and maintenance expenditures are projected to remain near 1.5 % of that value.

2. Argonne-West

As facilities at Argonne-West age, a high priority is progress each year toward replacement and refurbishment of various facility systems. Funding of about \$4 million is needed annually for the normal maintenance, repair, and upgrades that keep facilities functional and in compliance with escalating requirements in areas such as safety and environmental protection.

The GPP funding requirements at Argonne-West are affected by the age and condition of the plant and by continuing concern for the protection of employees, the public, and the environment. Throughout the last decade, GPP funding was well below requested levels. As a consequence, many needs were deferred, and a backlog was created. Adequate GPP funding will prevent premature deterioration or failure of facilities and systems resulting from deferred repair and will also ensure compliance with environment, safety, and health regulations and permits.

F. Assets Management, Space Management, and Inactive Surplus Facilities

In partnership with DOE, Argonne plans for, acquires, operates, maintains, and disposes of physical assets as valuable national resources. This stewardship of physical assets to meet the Laboratory's mission is accomplished in a cost-effective manner. The associated planning process

integrates programmatic, ecologic, economic, cultural, and social factors; considers the site's larger regional context; and includes the participation of stakeholders.

Under the current *Prime Contract* for operation of Argonne, management of site, facilities, and assets at Argonne-East continues to determine 5% of the fee received by the contractor. In preparation for the pending contract revision, Argonne has not identified any new performance measures that would directly reflect implementation of the *Strategic Facilities Plan*. The success of the *Strategic Facilities Plan* depends primarily on receipt of adequate funding for infrastructure and modernization, which the *Prime Contract* cannot assure.

1. Assets Management

Argonne's assets are acquired, rehabilitated, and upgraded to support the Laboratory's mission. DOE executes all real estate acquisitions through a Department-certified real estate specialist. All modifications and improvements are designed and constructed in compliance with applicable state, regional, and national building codes. The principles and practices of integrated safety management are fully integrated into the Life Cycle Asset Management processes by which Argonne implements site improvements. The result is a safe work environment achieved through safe work practices.

The DOE corporate physical assets database — FIMS — includes a current inventory of the Laboratory's physical assets. Periodically, this inventory is systematically reviewed, and the condition of the assets is assessed. Backlogs associated with maintenance, as well as with repairs and capital improvements, are managed through a systematic prioritization process. Integrity of all physical assets and systems is ensured through a configuration management process.

Surplus facilities identified through the Laboratory's planning process are reported to DOE in a timely manner. Assets are transferred between program offices through the process established by DOE. Disposal of real estate is subject to DOE approval. For the disposition of

nuclear facilities, the Laboratory develops a decommissioning turnover plan and, if appropriate, decontamination plans. A deactivation readiness review is completed before any physical work begins.

Retirement of surplus equipment is largely constrained by the backlog of GPE needs. Divestiture is usually limited to equipment still in use well beyond its original estimated service life. This equipment generally has little salvage value. Divestiture of surplus equipment and excess materials follows DOE guidelines.

2. Space Management

Argonne-East has long used a system of space charges that facilitates the allocation of annual infrastructure costs among various users. Occupants are assessed for costs on the basis of their use of assignable building space (which does not include general passageways, docks, or space for building equipment and mechanical systems). Space charges include recovery of sitewide expenditures for grounds, road repairs, snow-plowing, and other general utility and maintenance services. Building-specific charges reflect historical levels of maintenance for each particular building, custodial costs, and expenses for services such as sewer, water, electricity, and steam. Within buildings, services to production facilities, dedicated scientific and research apparatus, and other special-purpose equipment are metered separately for direct billing to users.

For the past decade, space utilization at Argonne-East has approached practical limits. Overall vacancy rates have averaged less than 2%, and now approach 1%. Vacancy rates for office space are less than 0.5%. Moreover, available space is usually in isolated small pockets that cannot be economically consolidated into a space large enough for a new work group (such as a group now working off-site).

3. Inactive Surplus Facilities

Inactive surplus facilities present significantly different challenges for the two Argonne sites.

a. Argonne-East

The DOE-EM funding for D&D of Argonne-East facilities no longer in use ended in April 2002.

More than 70% of the D&D work identified in the DOE-EM baseline for Argonne-East has been completed. The D&D of the JANUS reactor (Building 202) and the Argonne Thermal Source Reactor (Building 316) was completed, and the facilities are now available for reuse.

Argonne was in a position to complete by the end of FY 2003 all D&D activities identified in the approved baseline, if specified funding had continued to be provided. The site's two remaining contaminated surplus facilities (Buildings 330 and 301) were also identified as candidates for future DOE-EM funding that ultimately would support demolition. Two additional facilities, neither yet surplus, also require D&D: (1) the M-Wing hot cells in Building 200 (a partial facility), for which DOE-EM funding had been sought, and (2) the instrument calibration facility in Building 40 (the last remaining original building in the east area), whose D&D is to be supported by site operating funds.

Candidates for future DOE-EM support include parts of buildings, such as the M-Wing hot cells in Building 200 (which will become surplus by the time the transfer to DOE-EM begins) and the H-Wing high bay areas in Building 205. A further candidate is Building 330, for which no economically viable later use is foreseen.

Surplus facilities that are not contaminated have also been a long-standing concern at Argonne-East. Removal of facilities from the old 800 area is complete. Removal of Building 207 has facilitated planning for proposed expansion of the ATLAS complex. At the close of calendar year 2001, Argonne-East has completed demolition of approximately 84,000 square feet of space in obsolete metal Quonset huts in the east area and over 5,500 square feet in three ancillary masonry storage buildings. Following removal of Building 040, emphasis will shift to the selective removal of permanent, single-purpose buildings that can no longer function efficiently. The Laboratory will continue to remove abandoned or disconnected equipment, such as chillers.

The large majority of funding from the Office of Science Excess Facilities Disposition Program is no longer devoted to disposition of entire facilities. Primary emphasis has shifted to removal of excess equipment and broader mission support through risk reduction (e.g., removal of hazards), footprint reduction, cost savings (e.g., by elimination of surveillance and maintenance), and provision of building space and land for new research activities. In the middle years of the ten-year *Strategic Facilities Plan*, replacement facilities constructed with GPP funding will enable decontamination and disposal of several obsolete waste storage facilities (Buildings 325C, 329, and 374A), as well as replacement of the Emergency Services Department fire station (Building 333).

The last remaining obsolete structure in the site's east area, Building 40, will also require demolition after relocation of testing and calibration equipment and decontamination of the facility. Replacement of the aged bathhouse (Building 604) with a new facility satisfying the Americans with Disabilities Act will be undertaken as part of general rehabilitation of the site's student housing area.

Resource requirements for elimination of surplus facilities (both contaminated and uncontaminated, including D&D and surveillance and maintenance of facilities pending disposal) total \$42 million through FY 2008. In addition, environmental management and long-term stewardship of the site's natural assets and ecosystems will continue through the planning horizon. Wetlands management and hydrological characterization will be funded through operating funds from the DOE Office of Science as landlord, as will continuing (operating and maintenance) efforts to remove small areas of contamination and to maintain contaminated sites; funding required for these activities will total \$16 million through FY 2008.

b. Argonne-West

Currently, all facilities at Argonne-West are actively used, including many EBR-II systems that provide power switching, site monitoring, cooling water, compressed air, and other services to the entire site. Once deactivation of EBR-II is

complete, some associated facilities that do not provide such sitewide services may be classified as surplus if they are not used for other programs.

G. Energy Management and Sustainable Design

Energy efficiency and conservation are strong priorities at Argonne. The Laboratory benefits from continued participation in the demand-side load management program of its local electric distribution company, Commonwealth Edison. The Laboratory also pursues funding for energy conservation projects from the Federal Energy Management Program, and it assists DOE in (1) the development and implementation of facility retrofitting projects using energy savings performance contracts involving third-party financing and (2) the competitive procurement of electricity.

Argonne-East continues to be ahead of schedule in achieving the 30% reduction in energy usage by FY 2005 (and the 35% reduction by FY 2010) that are mandated by executive order. However, the Laboratory continues to encounter delays in obtaining DOE approvals for both the first project under the Super Energy Savings Contract program and the second project under the Utility Energy Savings Contract program. These two projects have a combined total estimated cost over \$3 million.

The current electric utility contract for Argonne-East is between DOE's Argonne Area Office and Commonwealth Edison. The resulting cost of electricity is the lowest available to the Laboratory. Natural gas is supplied through a supply contract and a separate delivery contract. The gas is purchased as a commodity through a Defense Logistics Agency supply and transportation contract, which assures the Laboratory of the lowest available cost. Nicor, Inc., provides distribution and storage services for the delivered gas. DOE's Argonne Area Office also holds the gas contracts for Argonne-East. The Laboratory provides technical support to DOE for evaluating and selecting the site's utility contracts.

The Laboratory continues to develop concepts for reducing the cost of the basic energy

commodities it purchases. Argonne-East has reduced the cost of natural gas for its boiler plant by taking advantage of its physical location along interstate gas pipelines and the resulting opportunity to bypass service from the local distribution company. The Laboratory is now in its second three-year, special-rate delivery service contract with Nicor, Inc. The Laboratory agrees not to bypass the Nicor system in exchange for a reduced rate for natural gas distribution. Argonne-East also saves on coal purchases by making an annual lump sum bid. Coal is then trucked to the site as needed.

It is a formal Argonne policy to incorporate strategies for sustainable design and pollution prevention into all design and construction projects. Sustainable design strategies are integrated at the initial stages of new projects through use of the Environmental Evaluation Notification Form, which considers both sustainable design and pollution prevention. The Laboratory also provides training, resources, and support for sustainable design and pollution prevention to managers of projects throughout design, construction, and demolition. For more detailed information, see the web page for the Argonne-East Pollution Prevention Program (URL: <http://p2.pfs.anl.gov/>).

H. Third-Party Financing

Argonne-East remains a leader in the use of collaborative funding to develop needed facilities. A prominent recent example is funding by the state of Illinois for the design and 1997 construction of the APS housing complex (Building 460), a facility providing 124,000 square feet of space. The state of Illinois has also shown interest in providing collaborative funding for future science facilities that would serve major Laboratory initiatives discussed in Chapter III, including a nanoscience building, an office building adjoining the Rare Isotope Accelerator (RIA), a computer and computational science building, and a genomics building at the APS. The state has already appropriated partial funding for the nanoscience and RIA buildings.

Table S3.2 Major Construction Projects^a (\$ in millions BA)

	TEC	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Funded Projects									
<i>AF-95</i>									
Office of Nuclear Energy, Science and Technology									
Nuclear Energy Research and Development									
General Plant Projects, ANL-West ^b	0.5	-	0.5	-	-	-	-	-	-
<i>FS-10</i>									
Office of Science									
Field Security									
General Plant Projects, ANL-West ^b	3.4	1.4	2.0	-	-	-	-	-	-
<i>KB-04</i>									
Office of Science									
Nuclear Physics									
Accelerator Improvements, ANL-East ^b	0.8	0.4	0.4	-	-	-	-	-	-
<i>KC-02</i>									
Office of Science									
Basic Energy Sciences									
Materials Sciences									
Advanced Photon Source									
Accelerator Improvements, ANL-East ^b	8.0	4.1	3.9	-	-	-	-	-	-
<i>KC-03</i>									
Office of Science									
Basic Energy Sciences									
Chemical Sciences									
General Plant Projects, ANL-East ^b	10.2	4.8	5.4	-	-	-	-	-	-
<i>39-KG-01</i>									
Office of Science									
Multiprogram Energy Laboratories — Facilities Support									
General Purpose Facilities									
Central Supply Facility (MEL-001-006)	5.9	0.1	-	-	-	-	-	-	-
<i>39-KG-02</i>									
Office of Science									
Multiprogram Energy Laboratories — Facilities Support									
Fire Safety Improvements - Phase IV (MEL-001-009)	8.4	6.0	2.0	-	-	-	-	-	-
Environment, Safety, and Health Support, ANL-East									
Environment, Safety, and Health Compliance									
Mechanical and Control Systems Upgrade - Phase I (02-CH-056)	9.0	-	1.0	2.8	5.2	-	-	-	-

Table S3.2 Major Construction Projects^a (Cont.)

	TEC	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Funded Projects (Cont.)									
<i>KP-11</i>									
Office of Science									
Biological and Environmental Research									
Life Sciences									
General Plant Projects, ANL-East ^b	3.0	3.0	-	-	-	-	-	-	-
TOTAL FUNDED PROJECTS	49.2	19.8	15.2	2.8	5.2	0.0	0.0	0.0	0.0
Budgeted Projects									
<i>AF-95</i>									
Office of Nuclear Energy, Science and Technology									
Nuclear Energy Research and Development									
General Plant Projects, ANL-West ^b	2.3	-	-	2.3	-	-	-	-	-
<i>FS-10</i>									
Office of Science									
Field Security									
General Plant Projects, ANL-West ^b	1.0	-	-	1.0	-	-	-	-	-
<i>KB-04</i>									
Office of Science									
Nuclear Physics									
Accelerator Improvements, ANL-East ^b	0.4	-	-	0.4	-	-	-	-	-
<i>KC-02</i>									
Office of Science									
Basic Energy Sciences									
Materials Sciences									
Advanced Photon Source									
Accelerator Improvements, ANL-East ^b	6.3	-	-	6.3	-	-	-	-	-
<i>KC-03</i>									
Office of Science									
Basic Energy Sciences									
Chemical Sciences									
General Plant Projects, ANL-East ^b	10.5	-	-	10.5	-	-	-	-	-
TOTAL BUDGETED PROJECTS	20.5	0.0	0.0	20.5	0.0	0.0	0.0	0.0	0.0
TOTAL FUNDED AND BUDGETED PROJECTS	69.7	19.8	15.2	23.3	5.2	0.0	0.0	0.0	0.0

Table S3.2 Major Construction Projects^a (Cont.)

	TEC	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Proposed Projects									
<i>AF-95</i>									
Office of Nuclear Energy, Science and Technology									
Nuclear Energy Research and Development									
General Plant Projects, ANL-West ^b	15.0	-	-	-	2.0	2.3	3.4	3.6	3.7
<i>39-AF-95</i>									
Office of Nuclear Energy, Science and Technology									
Nuclear Energy Research and Development									
Remote Treatment Facility	81.7	-	-	-	9.0	18.9	16.7	25.3	9.9
<i>FS-30</i>									
Assistant Secretary for Environmental Management									
Safeguards and Security - Environmental Management									
General Plant Projects, ANL-West ^b	2.2	-	-	-	1.0	0.3	0.3	0.3	0.3
<i>KB-04</i>									
Office of Science									
Nuclear Physics									
Accelerator Improvements, ANL-East ^b	3.2	-	-	-	0.6	0.6	0.7	0.6	0.7
<i>KC-02</i>									
Office of Science									
Basic Energy Sciences									
Materials Sciences									
Advanced Photon Source									
Accelerator Improvements, ANL-East ^b	63.0	-	-	-	13.1	14.2	11.9	11.9	11.9
<i>39-KC-02</i>									
Office of Science									
Basic Energy Sciences									
Materials Sciences									
Advanced Photon Source									
Center for Nanoscale Materials	76.0	-	-	7.8	25.1	43.1	-	-	-
<i>KC-03</i>									
Office of Science									
Basic Energy Sciences									
Chemical Sciences									
General Plant Projects, ANL-East ^b	71.4	-	-	-	13.4	14.5	15.6	14.5	13.4
<i>39-KG-01</i>									
Office of Science									
Multiprogram Energy Laboratories — Facilities Support									
General Purpose Facilities									
New General Purpose Facilities									
Multiprogram Laboratory Office Building (03-CH-007)	12.0	-	-	-	-	12.0	-	-	-
Multiprogram Computational Facility	32.3	-	-	-	-	-	-	32.3	-
General Purpose Laboratory Facility	5.9	-	-	-	-	-	-	-	5.9

Table S3.2 Major Construction Projects^a (Cont.)

	TEC	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Proposed Projects (Cont.)									
Building Rehabilitation and Upgrade									
Upgrade Existing Facilities									
Building Electrical Service Upgrade - Phase II (04-CH-062)	8.7	-	-	-	0.6	5.1	3.0	-	-
Building Roof Replacements	16.5	-	-	-	-	16.5	-	-	-
Mechanical and Control Systems Upgrade - Phase II	10.5	-	-	-	-	10.5	-	-	-
Laboratory Space Upgrade - Phase I	12.0	-	-	-	-	-	12.0	-	-
Building Electrical Service Upgrade - Phase III	11.0	-	-	-	-	-	-	11.0	-
Mechanical and Control Systems Upgrade - Phase III	10.8	-	-	-	-	-	-	-	10.8
Laboratory Space Upgrade - Phase II	12.9	-	-	-	-	-	-	-	12.9
Building Electrical Service Upgrade - Phase IV ^c	11.0	-	-	-	-	-	-	-	-
Laboratory Space Upgrade - Phase III ^c	12.9	-	-	-	-	-	-	-	-
Building Electrical Service Upgrade - Phase V ^c	7.7	-	-	-	-	-	-	-	-
Mechanical and Control Systems Upgrade - Phase IV ^c	9.9	-	-	-	-	-	-	-	-
Laboratory Space Upgrade - Phase IV ^c	11.0	-	-	-	-	-	-	-	-
Upgrade Utilities									
Sitewide Communications System Upgrade	7.5	-	-	-	7.5	-	-	-	-
Roads-Parking-Walks-Street Lighting Upgrade	13.5	-	-	-	-	-	-	13.5	-
Electrical System Upgrade - Phase IV ^c	11.3	-	-	-	-	-	-	-	-
39-KG-02									
Office of Science									
Multiprogram Energy Laboratories — Facilities Support									
Environment, Safety, and Health Support, ANL-East									
Environment, Safety, and Health Compliance									
Fire Safety Improvements - Phase V	6.2	-	-	-	-	6.2	-	-	-
Building 362 Asbestos Abatement ^c	5.7	-	-	-	-	-	-	-	-

^aThis table excludes construction funded from non-DOE sources.

^bGeneral Plant Projects and Accelerator Improvements are not line-item construction projects in the President's Budget; other projects in the table are.

^cTo begin after FY 2008.

Supplement 4: Other Charts and Tables

This supplement contains charts and tables characterizing Argonne's activities in the following areas:

- Science and math education
- User facilities
- Subcontracting and procurement

A. Science and Math Education

Table S4.1 characterizes Argonne's existing educational programs. The total number of appointments and the number of minorities and women are shown for FY 2000 and FY 2001.

B. User Facilities

Table S4.2 describes experimenters at the Argonne user facilities that have been officially designated as such by DOE. In highly abbreviated terms, these facilities provide the following important scientific capabilities:

- *Advanced Photon Source*: Became operational in 1996, providing superintense X-ray beams meeting research needs in virtually all scientific disciplines and many critical technology areas; accommodates national research

centers in basic energy sciences, advanced synchrotron radiation instrumentation, and structural biology, as well as academic and industrial research teams.

- *Intense Pulsed Neutron Source*: Accelerates protons to obtain neutrons, which are particularly valuable for the study of materials through analysis of the motions and structures of atoms.

- *Argonne Tandem-Linac Accelerator System*: Accelerates ions of heavy elements for studies of their reactions, to advance basic understanding of the properties of atoms and atomic nuclei.

- *Electron Microscopy Center*: Provides transmission and scanning electron microscopy for high-spatial-resolution imaging, microanalysis, and *in situ* studies, including studies of *in situ* ion irradiation and implantation effects in metals, semiconductors, and ceramics.

C. Subcontracting and Procurement

Table S4.3 describes Argonne's subcontracts and procurements from universities. Table S4.4 describes procurements from small or disadvantaged businesses.

Table S4.1 Participation in Science and Math Educational Programs

Program	FY 2000			FY 2001			FY 2002
	Total	Under- represented Minorities ^a	Women	Total	Under- represented Minorities ^a	Women	Projected Total
Students							
Instructional Laboratory ^b	3,170	998	1,425	3,433	830	1,323	3,500
Instructional Vehicle	4,682	2,776	2,510	6,374	2,714	3,284	6,500
Student Conference	226	-	215	284	-	284	300
Teachers							
Argonne Community of Teachers	38	17	30	32	17	25	35
Chemistry Workshop	28	2	22	21	-	16	29
Educational Network Consortium	5,757	-	-	5,912	-	-	6,000
Undergraduate Programs							
Summer Energy Research Participation Program	228	29	85	224	32	78	225
Semester Energy Research Participation Program	61	14	24	46	8	15	50
Community College Initiative	21	11	8	23	9	10	20
Undergraduate Research Symposium	130	-	-	131	-	-	200
Graduate Programs							
Graduate Students — Thesis and Practicum	129	3	38	132	4	43	135
Postdoctoral Fellows	208	5	34	190	8	46	200
National School on Neutron and X-ray Scattering	61	7	22	60	4	21	60
User Programs	-	-	-	608	-	-	700
Faculty Programs							
Faculty Research Participation	25	2	6	31	5	5	30
Sabbatical Leave	8	0	1	6	0	1	6
Faculty Visits	55	3	7	61	3	10	60

^aUnderrepresented minorities include African-Americans, Hispanics, and Native Americans.

^bInstructional laboratory numbers include all educational levels and Argonne Information Center participants.

Table S4.2 Experimenters at Designated Argonne User Facilities — FY 2001

User Affiliation	Number of Individual Experimenters	Number of Organizations Represented	Percent of Use ^a
Advanced Photon Source			
Argonne	231	1	27
Other DOE Laboratories	95	9	5
Non-DOE U.S. Government	30	6	4
U.S. Universities	1,054	101	34
U.S. Industry	210	33	23
Foreign Government Laboratories	31	5	1
Foreign Universities	209	50	4
Foreign Industry	18	6	1
Other	111	25	1
Total	1,989	236	100
Intense Pulsed Neutron Source^b			
Argonne	65	8	27
Other DOE Laboratories	31	7	13
Non-DOE U.S. Government	0	0	0
U.S. Universities	98	61	41
U.S. Industry	15	9	6
Foreign Government Laboratories	0	0	0
Foreign Universities	31	21	13
Foreign Industry	0	0	0
Other	0	0	0
Total	240	106	100
Argonne Tandem-Linac Accelerator System			
Argonne	45	1	53
Other DOE Laboratories	4	3	0
Non-DOE U.S. Government	1	1	0
U.S. Universities	43	18	31
U.S. Industry	0	0	0
Foreign Government Laboratories	4	4	4
Foreign Universities	26	11	12
Foreign Industry	0	0	0
Other	0	0	0
Total	123	38	100
Electron Microscopy Center			
Argonne	54	1	71
Other DOE Laboratories	0	0	0
Non-DOE U.S. Government	0	0	0
U.S. Universities	19	7	17
U.S. Industry	0	0	0
Foreign Government Laboratories	8	5	5
Foreign Universities	7	7	7
Foreign Industry	0	0	0
Other	0	0	0
Total	88	20	100

^aPercentage of experimental activity or use. Time devoted to maintenance or upgrading of the facility is not included.

^bFor the Intense Pulsed Neutron Source, the percent of use was calculated from the numbers of individual users, not from experimental time.

Table S4.3 Total External Subcontracting and Procurement (\$ in millions)

Source	FY 2001	FY 2002	FY 2003	FY 2004
Universities	12.3	12.0	12.0	12.0
All Other	131.0	126.5	126.5	126.5
Transfers to Other DOE Facilities	19.2	18.5	19.5	19.5
Total External Subcontracts and Procurement	144.8	140.0	140.0	140.0

Table S4.4 Procurement from Small or Disadvantaged Businesses (\$ in millions)

Source	FY 2001	FY 2002	FY 2003	FY 2004
Procurements from Small or Disadvantaged Businesses	61.5	60.0	61.0	62.0
Percent of Annual Procurement	50.3	48.0	48.5	49.0